4.0 ENVIRONMENTAL CONSEQUENCES

The major issues associated with the proposed action are public health and safety; occupational worker health and safety; cultural (archaeological and historic) resources; endangered, threatened, or sensitive species; land ownership and use; and socioeconomic impacts. While potential impacts of the proposed SRS on other environmental attributes also are analyzed in this section, they are of only minor importance.

A summary of the comparative environmental effects of the proposed action and the two alternatives (no action and minimal SRS infrastructure) is provided in Table 55 on page 301. For the convenience of the reader, this information also is provided in Table 32. The purpose of this table is to fulfill the requirements of the CEQ regulations that the impacts of the proposed action and the alternatives be presented in comparative form in order to provide a clear basis for a choice among options (40 CFR §1502.14). A comparative discussion of the impacts of each alternative, including the proposed action, also is contained in this section. In general, the amount of detail presented with respect to the various environmental parameters addressed in this section is proportional to the potential for adverse impacts.

Measures to mitigate possible adverse environmental consequences are discussed in this section as well as Subsection 2.1, beginning on page 10, which describes the proposed action. These measures are restated and summarized in Section 5.0, beginning on page 306. Regulatory requirements, discussed in Section 2.0, beginning on page 9, Section 3.0, beginning on page 89, and this section are presented in tabular form in Section 6.0, beginning on page 315.

Analyses Relating to Incomplete or Unavailable Information

In order to address uncertainties concerning potential environmental effects of a project, CEQ regulations allow preparation of an EIS when some the information related to evaluating “reasonable foreseeable significant adverse impacts” or a “reasoned choice among alternatives” is “incomplete or unavailable.” The CEQ regulations in 40 CFR §1502.22 require that the EIS make clear that this information is not available and that either the costs of obtaining it are exorbitant or the means of obtaining the information are not known. In such a case, those

Table 32. Comparison of Environmental Impacts of Proposed Action and Alternatives

Proposed Action and Alternatives	Proposed Action		Minimal Infrastructure		No Action Alternative	
Impact Element	Short-term[a]	Long-term[b]	Short-term	Long-term	Short-term	Long-term
Public Safety	No impact	Non-detect	No impact	Non-detect	No impact	No impact
Worker Safety	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Topography (Land Form)	Mod adv	Non-detect	Minor adv	Non-detect	No impact	No impact
Soils	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Paleontological Resources[1]	Minor adv	Non-detect	Non-detect	Non-detect	No impact	No impact
Surface Water Resources	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Surface Water Quality	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Ground Water Resources	No impact	Mod adv	No impact	Minor adv	No impact	No impact
Ground Water Quality[2]	No impact	Non-detect	No impact	Non-detect	No impact	No impact
Mineral Resources Extraction[3]	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Air Quality	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Vegetation	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Wildlife	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Threatened/Endangered Species[4]	No impact	No impact	No impact	No impact	No impact	No impact
Sensitive Species[5]	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Biological Diversity	Minor adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Cultural Resources[6]	Minor adv	Non-detect	Minor adv	Non-detect	Minor adv	Minor adv
Noise	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Private Land Ownership/Use[7]	Major adv	Major adv	Major adv	Major adv	No impact	No impact
Public Land Ownership/Use	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Visual and Aesthetic Resources	Minor adv	Major adv	Minor adv	Major adv	No impact	No impact
Recreation Resources	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Economy/Employment	Beneficial	Beneficial	Beneficial	Beneficial	No impact	No impact
Housing/Community Services	Non-detect	Non-detect	Non-detect	Non-detect	No impact	No impact
Transportation/Traffic	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Environmental Justice[8]	No impact	No impact	No impact	No impact	No impact	No impact

Key:

a Short-term means construction period of approximately 2 years plus 6 to 12 months to achieve full operations.

b Long-term means full SRS operations for an indefinite period.

Major adv — Major adverse environmental impact
Mod adv — Moderate adverse environmental impact
Minor adv — Minor adverse environmental impact
Beneficial — Beneficial environmental impact
Non-detect — Nondetectable or immeasurable environmental impact

1 Any paleontological resources would be discovered during construction. Mitigation measures would be used to minimize adverse impacts.

2 No activities are proposed to be undertaken that would affect ground water quality. If there should be such effects, they would be nondetectable.

3 Access to approximately 27 sections of land—approximately 7% of the entire SRS—would have certain restrictions pertaining to mineral extraction. It is assumed that the remainder of the site would be open to mineral development under NMSLO requirements.

4 No Federally-listed or State-listed species of plants or animals have been discovered at the proposed SRS site although two species of cactus were found that were down-listed from the New Mexico endangered species list in October 1995.

5 Sensitive species include Federally or State-listed threatened and endangered species as well as candidate species not yet listed and down-listed species that may be relisted.

6 "Minor adverse impacts" are designated for the no action alternative because prehistoric or historic archaeological sites would not receive tho same degree of protection as under the proposed action. For example, they would not be protected from vandalism or unauthorized removal under the no action alternative.

7 Present private landowners from whom land for the proposed SRS would be acquired are perceived to be impacted significantly although they would be adequately compensated for their land.

8 There would be no disproportionately high and adverse human health or environmental impacts on low-income or minority populations in the area of the proposed SRS. All ethnic and economic groups would be affected, although some would either benefit or be adversely affected more than others.

preparing the EIS must use "credible scientific evidence" and generally accepted "theoretical approaches" for the impact assessment, provided that the analysis is "supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason."

There are three dimensions of proposed SRS operations for which information is unavailable and for which there is no credible scientific evidence or accepted theoretical approaches to analyzing impacts

- the design configurations of the RLVs proposed to be launched from the SRS and the associated public safety implications
- the number of tourists who might visit the SRS and/or desire to view vehicle launches
- the type and amount of commercial and/or industrial development that might result from SRS operations at some time in the future

At this time, an impact analysis of any of these three topics is purely speculative and conjectural.

4.1 OCCUPATIONAL AND PUBLIC SAFETY

The SRS would be designed to support the launch and recovery of the next generation of RLVs. It would be constructed and operated in a manner that would ensure an acceptable margin of safety for workers and the public. The vehicles to be operated would be vastly different from the current generation of ELVs, making it possible for them to operate safely from the SRS. Many flight safety issues would be addressed in the certification documentation that will be required for each vehicle design that would be launched from or land at the SRS.

This analysis uses a generally nonmathematical approach to the safety assessment. Ground safety is a major focus. Flight safety is examined only in a generic sense because the details of the vehicle design are not yet known.

4.1.1 PROPOSED ACTION

This subsection analyzes risks to both SRS workers and the general public. The assessment was conducted for both construction and operations.

4.1.1.1 Construction Phase

Nothing about the construction of the proposed SRS would set it apart from other construction projects of comparable magnitude and type. Construction of roads and the airfield can be compared with a highway construction project. Erection of various buildings and the cryogenic fuel plant would be qualitatively similar to the construction of almost any small industrial facility. These risks are routine for construction workers. The public would not be subjected to health and safety risks as a result of construction.

4.1.1.2 Operations Phase

Risks to Workers

Workers at the proposed SRS would be subjected to risk of injury from a number of sources that are discussed in the following subsections. There are two categories of workers. One category is involved directly with SRS flight operations. The other category is not involved directly in flight operations, for instance, office workers, security personnel, etc.

Worker Safety

A total of 6.8 million injuries and occupational illnesses were reported by private industry in the U.S. during 1994, resulting in an average rate of 8.4 cases for every 100 equivalent full-time workers. This information was taken from the annual survey of job-related injuries and illnesses by the U.S. Department of Labor's Bureau of Labor Statistics for the year 1994, the latest year for which complete information is available (DOL 1994).

A conservative estimate of the injury rate to the work force at the proposed SRS can be made by matching the industry-type in the U.S. Department of Labor survey with operations and activities that would be similar to the SRS once it becomes operational. Annual illness and injury rates of these industries would be indicative of the rates that could be expected at the SRS.

Table 33 shows a breakdown of the activities at the proposed SRS by Standard Industrial Classification (SIC) using the nationwide illness and injury rates for private industry in 1994. Using the airfield operations as an example, the data show that 9.7 people are injured annually per 100 people employed by private industry. Of these, 4.5 cases per year involve lost time (time away from work), and 5.2 cases result in no lost time.

Table 33. Estimate of SRS Illness and Accident Rates for 1994

SRS Work/Service/Operation/Activity	SIC Number	National I/A Rates[a] Total Case[b]	Lost Time	No Lost Time
Engineering and Management Services	8700	2.3	1.0	1.4
Construction Activities	1500	10.7	5.0	5.7
Electrical Work	1730	10.8	4.3	6.5
Cryogenic Plant Industrial Gases Production	2813	3.4	1.8	1.6
Airfield Operations	4580	9.7	4.5	5.2
Combination Utility Services	4930	10.9	5.0	5.9
Computer and Data Processing	7370	13.6	5.0	8.6
Miscellaneous Repair Shops	7690	8.9	4.1	4.8
Special Warehousing and Storage	4226	15.0	8.2	6.9

a The Illness/Accident Rates are based on the numbers of occupational illnesses and injuries to a common exposure base of 100 full-time workers (200,000 working hours) (OSHA 1986).
b Total cases may not equal lost time + no lost time because of round off.

Data Source: DOL 1994

These statistics would be useful to safety personnel at SRS because they indicate which work activities would have the greatest potential for causing injury. Besides overseeing launch operations safety, safety personnel would focus their attention on jobs that would have the greatest potential for injury. Overall site safety would be accomplished through

- A job-hazard analysis process that would identify foreseeable safety concerns, assess the probability of occurrence, assess the degree of adverse consequences, and select mitigation measures to control or eliminate risks.
- Safety criteria identified in the SRS Operating License and the LSSOD.
- Safety procedures and instructions of the ES&H Manual.

The LSSOD and ES&H Manuals are discussed in Subsection 2.1.5.3, beginning on page 40.

Risks Associated with Cryogenic Fuels

Hydrogen is a flammable gas that forms an explosive mixture with oxygen or with air. It is extremely buoyant and dissipates rapidly when not in a confined space. Oxygen strongly supports combustion but is not explosive by itself. In their liquid form these materials are very cold (liquid hydrogen boils at –422°F and liquid oxygen boils at –297°F), which necessitates special handling. Workers must be equipped with protective equipment designed to prevent contact with the eyes or skin, and vapors must be kept away from sources of ignition and flammable materials.

A leak in the liquid hydrogen storage tank could lead to an explosion, but an explosion of the entire stored quantity could not occur because the available oxygen would be insufficient. Even though rapid combustion would occur, there would be little explosive energy if the storage vessel ruptured. Physical separation between the liquid hydrogen and liquid oxygen storage vessels would minimize the potential for any explosion capable of affecting areas accessible by the public. Standard industry practices pertaining to safe siting would be followed for production and storage facilities.

In the Unites States, large quantities of hydrogen are manufactured and shipped annually. For example, Air Products and Chemicals, Inc., manufactures 9 billion standard cubic feet and ships 70 million gallons in liquid form every year. They have never had a transportation accident that involved leakage of liquid hydrogen (Air Products, pers. comm., 1995). Even if such an accident were to occur, the effect would likely be less severe than a liquid petroleum spill. Hydrogen dissipates very rapidly, and hydrogen fuel fires produce less heating of nearby areas than hydrocarbon fuel fires. Because it is anticipated that the fuel plant would require a minimal work force; few if any personnel would be at the site if an accident were to occur.

In terms of explosive potential, the largest explosion would occur with a completely fueled space vehicle at or shortly after launch because large quantities of liquid hydrogen and liquid oxygen would be in close proximity. The fueled vehicle is estimated to contain 833 tons of liquid oxygen and 137 tons of liquid hydrogen. Estimates of the explosive yield of liquid hydrogen/liquid oxygen explosions can be as low as 1% of the equivalent weight of TNT or as high as 60%, depending on the circumstances. Work still in progress by NASA may indicate that 20% is the best estimate of the explosive yield of liquid hydrogen/liquid oxygen explosions in situations similar to those encountered with space vehicles undergoing massive impact damage (NASA, pers. comm., 1996). For typical launch vehicle failures, using 60% as a conservative estimate and using information in U.S. Army DARCOM Regulation 385-100 (DA 1981), the safe distance from such an explosion would be 6,200 feet. At 20% yield, the distance would be 3,675 feet. Either radius would ensure that the affected area would be contained entirely within the safety exclusion zone surrounding the launch/landing complex. There would be no workers within this area during launch.

Risks Associated with Near-Launch Pad Vehicle Failures

Another category of accident analyzed was a vehicle failure after the vehicle has left the immediate launch pad area. Trajectories of vehicles that would be launched from the proposed SRS would be much different from those of conventional launch vehicles, including the Space Shuttle. Figure 8, on page 40, is a graphic depiction of the expected RLV trajectory (altitude versus downrange distance) compared with a conventional trajectory. The RLV would not exceed a horizontal distance of 5 miles from the launch pad until it had reached an altitude of 60,000 to 120,000 feet at about 100 to 130 seconds into the flight. By contrast, a conventional launch vehicle typically pitches over shortly after launch and exceeds the 5-mile horizontal distance from the launch pad at an altitude of about 45,000 feet approximately 70 seconds into the flight. Experience has shown that propulsion failure is the most common type of vehicle failure. Flight control systems have a greater degree of redundancy built in that reduce the likelihood of total control failure.

Should a launch vehicle lose thrust, lose control, or break-up as it travels along its trajectory, the vehicle or its debris may impact on the ground. Each point along the trajectory would result in impact within a different "footprint." Missile flight safety specialists use the term instantaneous impact prediction (IIP) to refer to this footprint. In the event of crash landing of an intact vehicle, the IIP is the area within which the vehicle would have a high probability of impacting. In the event of vehicle break-up, the IIP is the area that would have a high probability of containing all of the debris. The IIP is affected by vehicle speed and altitude, by the nature of the break-up event, and by atmospheric conditions, particularly the wind.

Conventional launch vehicles, even manned vehicles, are equipped with flight termination systems that usually function by explosively destroying the vehicle. These vehicles cannot recover from any but the most minor of anomalies. An anomaly requiring destruction of the vehicle beyond the first 60 seconds or so of flight would result in the intact vehicle or debris from its destruction falling outside a 5-mile radius from the launch site. The RLV, on the other hand, would be nearly straight up from the launch pad for more than the first 2 minutes of flight. Because the vehicle would be designed to land, it would be possible to recover from many more types of anomalies.

If a safe landing could not be achieved, the intact vehicle or its debris might fall outside the 5-mile radius safety zone, but because of the vertical trajectory during the initial phase of the launch, the debris would not be expected to travel as far down range as that from the destruction of an ELV. At 20% explosive equivalent by weight, the propellant could scatter debris over a radius of 3,675 feet if the explosion occurred at liftoff. An explosion above ground could produce a somewhat larger debris pattern for a given quantity of fuel, but the quantity of fuel would be continually decreasing. Workers would be evacuated from the safety zone during launch.

Risks Associated with Launch Vehicle Failure Outside the 5-Mile Radius

Risk of injury to SRS workers resulting from vehicle failure outside the 5-mile radius would be lower than the risk associated with failure within the 5-mile radius. A return-to-launch-site maneuver would result in the vehicle reentering SRS airspace. For such a maneuver to be successful, the vehicle must be under good control. Risks would be comparable to those associated with normal landing.

Risks Associated with Vehicle Failure During Landing

After reentering the atmosphere, the vehicle would use aerodynamic braking to reduce its speed in preparation for landing. An anomaly during reentry, braking, or landing could result in crash landing of the vehicle or in its breakup. Either case could possibly endanger workers. Because there would be much less fuel on board compared with launch, the consequences of such an accident might be less severe than the consequences of a launch accident.

Summary of Risks to Workers

Risks to workers at the SRS associated with all activities would be comparable to the risks resulting from similar activities taking place at other types of facilities. No mission would be approved for launch from the SRS unless acceptable safety criteria were met as established by FAA/AST.

Transportation Safety

A transportation accident could affect both the equipment operator and members of the public. Most equipment and supplies for the SRS would be transported to the site by commercial truck. The rate of large truck accidents involving fatalities or injuries was 58.7 per 100 million miles for 1994, the latest year for which complete statistics are available (NHTSA 1995). The number of accidents that would be attributed to the SRS was estimated using the assumption that

- each delivery to the SRS would involve a commercial truck making a 500-mile round trip
- there would be 2 deliveries per day for a total of 730 deliveries per year

Total truck mileage would be 500 miles × 730 trips = 365,000 miles per year. Therefore, likelihood that a truck traveling to or from SRS would be involved in an accident resulting in injury or death to the operator or to other people is one in every 4.7 years.

Although there would be air and rail shipments, both means of transportation are safer than highway transportation. Furthermore, there would be fewer shipments by these two conveyances. Therefore, air and rail accidents are expected to be more rare and were not analyzed in detail.

Risks to the Public

Many of the risks to which SRS workers would be exposed would not put the public at risk. The SRS would provide a large buffer zone around the cryogenic fuel plant and the other infrastructure. The public would not be subject to routine occupational hazards on site. Risks associated with operations of the cryogenic fuel plant and with operation of space vehicles are analyzed in the following section.

Risks Associated with Cryogenic Fuels

Members of the public and uninvolved workers would never be permitted close enough to the cryogenic fuel plant, to fueling operations, or to a fueled vehicle to be in danger.

Oxygen, hydrogen, and their combustion product, water, are not air pollutants. A leak or spill of hydrogen or oxygen, or water formed by the combustion of hydrogen, would pose no risk of ground or water contamination, and there would be no residue that would require reporting to the National Response Center. Liquid hydrogen, if spilled, would rapidly vaporize and the resulting gas would rise rapidly. It would pose no danger beyond the immediate area of the spill. Oxygen is slightly heavier than air, especially when cold. It enhances combustion and sometimes supports combustion of otherwise difficult to burn materials, but it poses no danger of toxicity to personnel.

A hypothetical spill of liquid hydrogen and liquid oxygen was analyzed. Concentrations were estimated using the EPA dispersion model SCREEN (EPA 1991). It was assumed that the entire stored quantity of either material was released in an area 40 feet square over a period of one hour. The predicted increase in the concentration of gaseous oxygen at the nearest SRS boundary, approximately 5 miles from the spill, would be 5,000 parts per million or approximately 2.5% over the normal atmospheric concentration of oxygen, which is about 200,000 parts per million. This increase would be insufficient to greatly enhance combustion. A similar calculation for hydrogen indicates a conservative concentration of 1% at the SRS boundary, much less than the 4% lower limit of flammability.

Risks Associated with Near-Launch Pad Vehicle Failures

As analyzed previously, an unplanned event while the vehicle is within a 5-mile radius of the launch pad could result in

- an unplanned but safe landing of the vehicle
- crash landing of the intact vehicle
- impact of debris

When the vehicle is within a 5-mile radius of the launch site, the public would be at minimal risk because people not essential to the project would be excluded from the safety zone. While it is possible that debris would fall outside the 5-mile radius, the vehicle would have little horizontal momentum within this zone. The debris most likely to fall outside this radius would be the lighter, less dangerous components that could be carried long distances by the wind. This debris could pose a hazard to aircraft. Although direct impact of small debris would be unlikely to result in destruction of an aircraft, debris ingested into an engine could result in catastrophic damage.

Risks Associated with Launch Vehicle Failure Outside the 5-mile Radius

For each vehicle and flight path, a rigorous flight safety analysis would be conducted in the following manner:

- All possible vehicle failure modes and their probabilities at each point in the flight would be determined. Much of this could be done with detailed analysis of the design, but flight experience would provide the confirmation.
- The consequences of each failure mode would be assessed. Depending on circumstances, the vehicle might make an emergency landing, it might fall to earth essentially intact, or it might break up because of aerodynamic effects. The analysis would require knowledge of the behavior of the vehicle or its debris after each failure. For example, after a break up, required factors would include the number of pieces, their sizes and weights, their composition, and their initial velocities with respect to the center of mass. These factors would depend on the design and construction of the vehicle.

- The trajectory of the vehicle would be required. If it remains intact, an impact point is required. If it breaks up, an estimate of the dispersion of the fragment and the center of the pattern is required. Impact analysis would depend on the initial trajectory.
- The state of that part of the atmosphere through which the vehicle or its debris would fall would be required, particularly the wind patterns. High winds, for example, might significantly displace debris, especially small debris.
- Detailed population data along the flight path (number and distribution of people) would be used to compute the probability of casualty for each failure at each point in the flight. The concept of dwell time must be considered. As the vehicle gains speed, it passes over areas of a given size in shorter and shorter times. At Mach 2 (approximately 1,500 mph), it would pass over a 1,000-ft long area in about 0.5 second. At Mach 10, the time would be less than 0.1 second. Only if a failure were to occur in a specific, very short time interval would an individual in any given area be at risk of injury. Large debris falling onto a densely populated city would have a high probability of injuring people on the ground, but the same debris falling onto a sparsely populated area, such as the proposed SRS, would have a much lower probability of causing injuries. This analysis can be quite complex because many factors must be considered. For example, a house or automobile would afford good protection against small debris, but impact of large debris or the intact vehicle could collapse a building and injure people inside who otherwise would not be stuck.
- At every point in the flight, each possible failure would be analyzed, the debris propagated to the ground, and the expected casualties computed. In practice, it is possible to perform the calculations at a smaller number of points and accurately predict the risk for the entire flight path.
- The results for all points would be summed to yield the final probability of casualty or individual risk.
- These values would then be compared with risk criteria established by FAA/AST.

This is a very time consuming process even with the aid of a fast computer because there are several failure modes, the calculations are complex, and they are repeated at many points in the flight.

The RLVs to be flown from the proposed SRS have not been designed. Therefore, data on both the potential failure modes and on consequences of each type of failure are unavailable and a rigorous risk assessment cannot be completed. This lack of information is acknowledged as required by CEQ

Regulation 1502.22. Beginning on page 175 is an unnumbered subsection discussing of the use of incomplete or unavailable information. In lieu of a detailed risk assessment for specific vehicles, a more general risk and flight safety approach must be followed. These studies are still in progress, and will further refine the safety analysis. Additional studies will be conducted for specific vehicles and launch operations.

There would be no flight safety risks as a result of nominal operations because the RLVs to be operated from the SRS would not drop spent components. An accident during launch or landing could conceivably result in injury or death to people on the ground as a result of impact of the vehicle or the debris from its breakup. As discussed below, risks to the public would be controlled through a combination of high vehicle reliability and limitations on flight paths. It is anticipated that launch vehicles will be developed that will meet these standards. Vehicles would not be allowed to operate from the SRS unless and until they have been demonstrated to meet FAA/AST safety standards.

Risk of injury to the public associated with launch of a space vehicle can be controlled by either of two methods

- The vehicle can be launched on a trajectory that has a limited human population. If a failure should occur that leads to termination of the flight, the number of people potentially affected would be small.
- The reliability of the vehicle can be increased so that failure becomes extremely unlikely.

Mathematically, the overall risk of injury is proportional to the population density and inversely proportional to the reliability. Reducing population density or increasing reliability of the vehicle reduces the risk. An additional factor is that, as the vehicle gains speed, the debris impact footprint also moves faster and faster along the ground so that individuals are exposed to the risk for shorter periods of times. This effect is known as the dwell time, and it significantly reduces the risk exposure of people far down range from the launch site.

All past American space launches have relied primarily on controlling the number of people exposed to the risk. Most orbital launches have been conducted from the Kennedy Space Center over the Atlantic Ocean and from Vandenberg Air Force Base over the Pacific Ocean. Occasional over-water orbital launches have been conducted from other locations. Suborbital launch sites have included the over-water test ranges and inland ranges such as WSMR where a very large unpopulated land area is available. Even an over-water launch is not always completely free of risk to humans because there is the possibility that boats may stray into the potential impact area. Orbital flight trajectories generally must pass over land before the vehicle achieves orbit. With increasing speed, the dwell time decreases, and more of the debris would burn up before impact. As the vehicle approaches orbital speed, the potential impact area increases to include the entire band of overflown latitudes as dictated by the inclination of the orbit.

The SRS would control risk to the public by minimizing the exposed population, especially during the first two minutes of flight. It would, however, be the first space launch facility to rely to a great extent on vehicle design and vehicle reliability to control risk. This has not been done with previous U.S. space launches, although reliability is implicit in allowing conventional aircraft to overfly populated areas. This is not to say that launches would be conducted over highly populated areas. It is anticipated that RLVs eventually will prove to be sufficiently reliable that launches over highly populated areas can be accomplished with a margin of safety acceptable to the public. Detailed analysis of the vehicle and its parts by experts in the field of reliability and maintainability can be used to establish confidence in the design. Ultimately, reliability can be proven convincingly only with extensive flight experience. This will be neither easy nor inexpensive. Vehicles will be tested incrementally with initial test flights taking place over unpopulated areas, not from the SRS. Only after testing is complete would vehicles be allowed to operate from the SRS. Even then, until the actual flight data collected are sufficient to verify reliability projections, flights may be restricted to flight paths over regions with low enough population density to meet FAA/AST safety standards. Three flight paths that would overfly relatively small populations during the powered portion of launch are shown in Figure 29.

The advantages of RLVs can best be illustrated by comparison with ELVs. An ELV launch has a very limited fault tolerance. It has been demonstrated that launch of a liquid-fueled rocket can be aborted after engine ignition but before liftoff without loss of the vehicle. However, once the vehicle has committed to liftoff, the ability to recover from unplanned events is very limited. In addition to these considerations, most ELVs are staged vehicles that drop spent stages or boosters along the trajectory. Solid-fueled rockets are even less fault tolerant. Most solid-fueled rocket engines cannot be shut down once ignited. Partial loss of thrust, as might

Figure 29. Possible Flight Paths from the Proposed SRS with Limited Human Population

occur if one engine of a multiengined vehicle were to fail, typically would be sufficient to prevent the vehicle from reaching orbit. Flight controllers typically terminate the flight with an explosive charge. While debris presumably falls into an uninhabited area, the vehicle and payload are lost.

An RLV would be designed for landing as well as launching. In the event of an engine failure, depending on where in the flight the failure occurred, the vehicle could execute a return-to-launch-site maneuver, or it could abort the flight to a downrange landing area. A vertical landing vehicle would require less thrust to land than to launch because of the use of some fuel. It is reasonable to expect that it could land successfully with partial loss of thrust. In an emergency situation involving return to launch site, a horizontal landing vehicle may need to vent all or part of its fuel before landing to avoid exceeding the design limit of its landing gear, but these vehicles would be designed to land with little or no thrust. In the event that the flight controllers determine that the vehicle could not be saved, it is possible that a different approach to flight termination may be desirable. Rather than destroying the vehicle with explosives, it may be more reasonable to rapidly vent the fuel, perhaps with small explosive charges to rupture the fuel tanks, and to keep the vehicle largely intact.

Computerized mathematical models have been developed to predict the dispersion of debris resulting from space vehicle failures. These models have been tested by comparing their predictions with the results of actual breakups that have occurred. Existing models cannot be applied directly to RLVs, however, because many details of the RLV designs will be significantly different from conventional ELVs. Additional model development work, perhaps including theoretical analysis and laboratory measurements, will be required to develop confidence in model predictions. For example, existing launch vehicles consist largely of parts fabricated from conventional metal alloys. RLVs, in order to satisfy requirements for very low weight, will consist largely of composite materials, ceramics, and exotic metal alloys. It will be necessary to demonstrate the applicability of debris models to these types of structures.

Given a debris dispersion pattern for each point along the vehicle trajectory, it is possible to estimate the probability of injury to people on the ground. Any subset of the population, whether overflown by an RLV or not, would be expected to experience a certain number of injuries and fatalities resulting from a wide variety of risk factors. For many population subsets in the United States, motor vehicle accidents are a leading cause of injury and death, and people also are injured in falls, recreational activities, industrial accidents, and other types of activities. Table 34 contains examples of the annual risk of death resulting from various common activities and risk factors. The goal of this risk assessment is to help understand the added risk of living in the vicinity of the SRS or along one of its flight paths in the context of the wide range of risks to which the public is exposed.

Table 34. Annual Risk of Death Resulting from Various Common Activities

Activity or Cause	Individual's Chances of Dying from Cause in One Year
Coal mining	1 in 110
All causes in U.S.	1 in 115
Smoking	1 in 350
Fire fighting (occupation)	1 in 1,250
Motor vehicle use	1 in 4,500
Work (all industries)	1 in 8,800
Truck driving	1 in 10,000
Falls	1 in 13,000
Recreational swimming	1 in 45,000
Home accidents	1 in 83,000
Air travel (one trip)	1 in 500,000
Lightning	1 in 2,000,000

Data Source: Federal Aviation Administration/Office of the Associate Administrator for Commercial Space Transportation

An important factor in the risk analysis is the selection of appropriate risk criteria. Risk criteria include such factors as the minimum energy of a piece of debris that would cause injury or death to a person struck, the minimum energy of a piece of debris that would cause catastrophic damage to an aircraft, and the risk to individuals along the flight path, expressed as a mathematical probability, that is considered acceptable by safety experts by FAA/AST, and ultimately by the public. Risk criteria are still under active consideration within the range and launch safety community. Different ranges sometimes use somewhat different criteria, and normally require their particular criteria to be employed for operations for which they are responsible. There is a trend toward standardization, however.

A factor in public acceptance of risk is perception. It has been observed that the public accepts risk from voluntary activities at a level approximately 10 times higher than risk from involuntary sources. Voluntary risk sources include operating motor vehicles and recreational activities such as skiing, swimming, and bicycling. Involuntary sources include environmental contamination and crime. Another factor in risk perception is control. Individuals are more willing to accept risk if it results from a situation in which they feel they are in control. For example, many people are more at ease with the risk of riding in a motor vehicle than in a commercial aircraft even though the risk of death per mile traveled is more than 40 times higher for automobile travel than for air travel.

No human activity, including space launch activity, is completely without risk. No matter how remote the possibility, there are circumstances that could result in injury or death to people on the ground from any space launch. Launches from the SRS would minimize these risks through careful selection of appropriate flight paths and through vehicle reliability as demonstrated by safety analyses, incremental testing, and flight experience. The SRS will be committed to limiting risk exposure within the constraints imposed by launch requirements. For example, otherwise desirable flight paths might not be used with vehicles that have an insufficient demonstration of reliability. A key factor in the safety of the SRS is that there would be no intentional dropping of spent stages or boosters. Only an anomalous event could result in injury to people on the ground.

Risks Associated with Vehicle Failure During Landing

As discussed under worker safety, after reentering the atmosphere, the vehicle may use aerodynamic braking to reduce its speed in preparation for landing. An anomaly during reentry, braking, or landing could result in crash landing of the vehicle or in its breakup. In either case, people along the trajectory would be at risk. Because there would be much less fuel on board compared with a launch, and less engine thrust would be required, the consequences of such an accident likely would be less severe than the consequences of a launch accident. The instantaneous impact prediction of a reentering space vehicle is initially far down range from the vehicle position, but it moves closer and closer to the actual vehicle position as it loses speed and altitude in preparation for landing.

Summary of Analysis of Risk to the Public

Based on expected FAA/AST licensing requirements (Subsection 2.1.2 on page 20) and current technological information, it is anticipated that risks to the public associated with operation of the SRS, including those associated with launching and landing space vehicles, would be less than other risks to which people living near the facility and along flight paths are routinely subjected. Appropriate risk and flight safety analyses would be conducted for specific vehicles and launch operations. No mission would be approved for launch from the SRS unless acceptable safety criteria were met as established by FAA/AST.

4.1.2 No Action Alternative

Under this alternative, the SRS would not be developed and there would be no risks of injury associated with the project to either workers or the public.

4.1.3 Minimal SRS Infrastructure Alternative

4.1.3.1 Worker Safety

Under this alternative, the full SRS complement of facilities would not be constructed. As an example, the cryogenic fuel plant would not be built. There would be fewer permanent buildings and less infrastructure would be needed. Risks to workers during construction would be smaller than under the proposed action because fewer facilities would be constructed and because many of the facilities would be prefabricated and merely transported to the SRS.

The work force possibly would be smaller, but the safety concerns would be essentially the same as discussed in the proposed action. There would be no change in the safety program from that of the proposed action. Launch operations safety and operational safety would still be the focus of the safety program. Launch site safety would be accomplished through establishment of operating license requirements and safety criteria specified in the LSSOD. Operational safety would be accomplished through establishment of a job-hazard analyses and operational requirements specified in the ES&H Manual.

4.1.3.2 Transportation Safety

Except for shipment of liquid hydrogen, oxygen, and nitrogen to SRS, less equipment and fewer supplies would be transported to the SRS by air, rail, or truck under this alternative. The cryogenic fuel plant would not be constructed; therefore, all cryogenic fluids would be transported to SRS by truck. This would involve transporting approximately 833 tons of liquid oxygen and 137 tons of liquid hydrogen per launch or approximately 100 to 150 truck loads. At the start-up of the facility, it is estimated there would be 5 launches per year.

The likelihood of a transportation accident resulting in injury or death would increase from that computed for the proposed action. The accident frequency at the start-up of SRS operations was computed using the assumptions that

- A truck would make a 2,000-mile round-trip for each delivery. It would be loaded in New Orleans, Louisiana, and return to there.
- There would be 750 deliveries per year (five launches at 150 loads per launch).

Total truck mileage would be 2,000 miles x 750 trips = 1.5 million miles per year. The likelihood of an accident resulting in injury or death to the operator or to other persons based on the national rate of accidents of 58.7 accidents per 100 million miles would be one accident every 1.14 years.

Typical industrial gas producers such as Air Products and Chemicals, Inc., maintain their own fleet of trucks and have established excellent fleet safety records. The rate for all accidents (a large majority of which do not result in injury or death) for the liquid/bulk transportation fleet accident for 1993 was 2.72 accidents per million miles (Air Products, pers. comm., 1995). An important fact from the Air Products experience is that in 29 years of operation, there has never been a release of liquid hydrogen as a result of a traffic accident. This record is based on an average of 70 trucks carrying a total of 70 million gallons of liquid hydrogen in 14,000 deliveries and driving 8 million miles per year.

4.1.3.3 Public Safety

Some risks to the public associated with operation of the SRS under the minimal infrastructure alternative would be the same as those under the proposed action, and some risks would decrease. Risks resulting from vehicle flight, would be essentially the same as those discussed as part of the proposed action. The small risks associated with the operation of the cryogenic fuel plant as analyzed for the proposed action would not occur under the minimal infrastructure alternative.

4.2 GEOLOGY

Impacts to the topography, soils, and paleontology from the proposed action and alternatives are discussed in this subsection. No impact to site geology or seismicity is anticipated from any of the SRS alternatives.

4.2.1 Topography

Changes to the topography of the site as impacted by the various alternatives are discussed below.

4.2.1.1 Proposed Action

Natural land forms within the project area would be altered by construction of the proposed SRS. Construction of a major industrial facility and development of a runway system, launch/landing pads, assembly buildings, a facility control center, and ancillary structures such as roadways, pipelines, and solid and sanitary waste disposal facilities would constitute alterations of land forms within the proposed boundary of the SRS. These alterations would affect the site's visual resources (Subsection 4.9, beginning on page 262) and existing drainage patterns. It is estimated that under this alternative, up to 1,110 acres would be disturbed (Tables 4 and 5, pages 49 and 58). The largest topography alterations would be associated with the proposed 12,000-foot runway.

4.2.1.2 No Action Alternative

If no action were taken to construct the proposed SRS site, there would be no effect on current landforms at the site.

4.2.1.3 Minimal SRS Infrastructure Alternative

The footprint of the disturbed area would be similar to the proposed action. In cases such as the SCCF, the footprint would the greater because temporary structures require a larger footprint for the same amount of floorspace. For example, a 10,000-square foot building could be constructed on an area of 100 feet × 100 feet. If the same floorspace area were provided in temporary structures (office trailers), the additional space needed between units would result in the footprint being larger. However, some facilities such as the cryogenic fuel plant would not be constructed so the net effect would be that the footprint would be similar. The impacts for this alternative would be similar to those of the proposed action.

4.2.2 Soils

Land within the proposed SRS would be subject to surface soil disturbance from activities such as clearing, leveling, and construction. Any soil lost as a result of accelerated erosion would be irretrievable. The areal extent of activities on SRS land would be limited and managed to protect the soil resource. Existing rights-of-way could be subject to surface and shallow subsurface soil disturbances from any new construction, maintenance activities, and increased vehicle activity within the right-of-way. New road construction could increase the soil susceptibility to wind and water erosion during construction activities; however, the new roads would be designed and constructed to decrease the potential for future erosion.

Thirteen soil types occur at and adjacent to the project area (Table 9 on page 93). The hazard of water erosion of soils ranges from slight to severe, and the potential for blowing soil is severe. During construction activities associated with the project, exposed soils would be susceptible to wind and water erosion. Standard construction practices, such as watering during construction and postconstruction reclamation discussed in Subsection 2.1.6.2, beginning on page 54, would be employed to mitigate soil impacts.

4.2.2.1 Proposed Action

Soil would be disturbed in all areas of construction. In the long term, wind and water erosion would decrease. Soils in those areas affected by construction of facilities and infrastructure would be stabilized by designs incorporating storm-water runoff controls and revegetation.

Approximately 0.3% of the project area would be impacted by the construction of facilities and infrastructure. The soil impacts associated with construction would include the leveling of land and removal and redistribution of soil during site construction. It is estimated that more than 4 million cubic feet of soil would be redistributed over and adjacent to the site during construction. Most of the soils within the proposed SRS construction site are 1 foot to 5 feet in thickness. Most of the organic matter contained in these soils resides within the top few inches. It would be impractical to strip and store the topsoil for restoration activities. Therefore, construction activities within the proposed area effectively would transform the majority of the disturbed areas. Additionally, during construction activities, soils likely would become airborne under windy conditions. Loss of soil would be minimized by adherence to standard construction practices (Subsection 2.1.6.2, beginning on page 54). Some amount of revegetation would be performed in disturbed areas.

Effects of removing the soil from the site include rangeland loss and associated grazing capacity, surface runoff flow alteration, channelization of erodible soils due to surface flow changes, and removal and decrease of vegetation. These impacts would be offset by beneficial effects from storm-water runoff controls around facilities, particularly in the area of the airfield, and by controls implemented to protect infrastructure built within the 100-year floodplain. Overall, construction activities would improve soil-erosion patterns.

4.2.2.2 No Action Alternative

If no action is taken to construct the proposed SRS site, there would be no affect upon soil conditions at the site.

4.2.2.3 Minimal SRS Infrastructure Alternative

The amount of land area disturbed by clearing and grading and resulting impacts would be similar to that under the proposed action.

4.2.3 PALEONTOLOGY

Because these resources are not known to be present within areas of proposed construction activity, impacts to the site paleontology from various alternatives are expected to be minimal. However, the possibility exists that buried, undiscovered fossils are present at the site, but the area is not noted for fossils. Impacts to these potential sites are discussed below.

4.2.3.1 Proposed Action

There would be little impact to the paleontology of the proposed site unless previously unknown fossil beds were discovered during construction activities. It should be noted that discovery of new fossil sites sometimes is a beneficial effect of projects such as the SRS.

4.2.3.2 No Action Alternative

If the SRS is not constructed, there would be no effect upon site paleontology.

4.2.3.3 Minimal SRS Infrastructure Alternative

The footprint of the disturbed area would be similar to the proposed action and the impacts would be similar.

4.2.4 MINERAL RESOURCE PRODUCTION AND USE

The following subsection describes the impact to mineral resource production and use under various alternatives. Generally, conversion of Federal and private land within the proposed boundary of the SRS would place site resources under State jurisdiction. Consequently, natural resources would fall under the provision of State leasing of these commodities. These provisions include applications and associated fees, potential withholding of certain State tracts, annual rental fees, and State royalties for production. Other requirements for State leasing are filing of performance bonds to ensure the payment of royalties and reclaim damages due to production or development. In the case of sand, gravel, caliche, and cinders, other requirements may include mine operation and reclamation plans and discussion of impacts to surface and subsurface water supplies from the proposed operations.

4.2.4.1 Proposed Action

The land within the boundary of the proposed SRS that currently is Federally or privately owned would be transferred to NMSLO ownership. NMSLO allows for the exploitation of salt, potash, oil and gas, coal, geothermal resources, and metallic (hardrock) minerals through State leases. Construction of the proposed SRS would impact mineral exploration and development by removing approximately 27 sections from these land uses.

Oil and Gas

Although there is moderate potential for hydrocarbon production within the proposed SRS site boundary, no production has occurred within or near the site, and all exploration of the site has ceased. There are no active Federal leases for oil and gas within or immediately adjacent to the proposed site; all leases either have been terminated, relinquished, or have expired.

Geothermal

Land within the boundary of the proposed SRS has low-to-moderate potential for development of geothermal resources. Although it is possible that geothermal resources occur within the boundaries of the proposed SRS, no obvious resources or active geothermal leases currently exist.

Because there are geothermal resources elsewhere in New Mexico, disposal of land within the boundary of the proposed SRS would not result in significant impacts. If geothermal leasing opportunities within the proposed site boundary are relinquished to the State, State leasing would be available for these resources. Geothermal exploration and development would be compatible with surface uses.

Coal

The proposed SRS area has not been developed for its coal resources. Mining of coal from outcrops west of the boundary has been conducted on a limited scale for local use, and no commercial production has been recorded from outcrops adjacent to the proposed SRS site. The limited thickness of the coals and considerable depth suggest that the potential to develop this resource within the boundary of the proposed site is low. Because there are vast resources of coal elsewhere in New Mexico and the United States, and because the quality of the coal is low to moderate, loss of potential development of coal resources within the boundary of the proposed SRS would not result in significant impacts. If the proposed site land were transferred out of Federal ownership to State ownership, leasing of any coal resources within the proposed site boundary through the State would become an option for this resource.

Sand and Gravel

Mining of sand and gravel within the proposed SRS boundary probably has been for local use, and no commercial production has been recorded within the proposed SRS site. The thickness of sand and gravel deposits suggest that the potential to develop this resource within the boundary of the proposed site is moderate to high. Because there are vast high quality resources of sand and gravel elsewhere in the general area, the loss of potential development of sand and gravel resources within the boundary of the proposed SRS would not result in significant impacts. If the proposed site land were transferred out of Federal ownership to State ownership, leasing and production of the sand and gravel resources within the proposed site boundary through the State would become an option.

Caliche

Mining of caliche within the proposed site boundary has not occurred, and no commercial production has been recorded within the proposed SRS site. The thickness of caliche deposits suggest that the potential to develop this resource within the boundary of the proposed site is moderate to high. Because there are vast resources of caliche elsewhere in the general area, loss of potential development of caliche resources within the boundary of the proposed SRS would not result in significant impacts. If the proposed site land were transferred out of Federal ownership to State ownership, leasing and production of caliche resources within the proposed site boundary through the State would become an option.

Locatable Minerals

Mineral claims have been filed within the boundary of the proposed SRS site, but no large-scale production of minerals has been identified. Gypsum may have been removed in limited quantities over many years and used for local agricultural purposes. Areas of large-scale, commercially exploitable mineralization within the site boundary appear to be restricted to gypsum resources.

This area has not been developed for its mineral resources nor are these resources currently considered economically recoverable. Mineralized areas adjacent to the proposed SRS site offer greater potential for economic mineral deposits. If mineral commodity prices were to rise, or if U.S. sources for strategic or critical mineral resources were no longer accessible, it is possible that those resources within the boundaries of the proposed SRS site may become economically recoverable.

Because there are vast resources of minerals elsewhere in New Mexico, loss of potential development of locatable minerals within the boundary of the proposed SRS would not result in significant impacts. Transfer of this land from Federal to State ownership would not affect the ability to mine locatable minerals, because State leasing of potential resources would become an option for mineral development within the proposed boundary of the SRS. Additionally, the opportunity to mine mineral resources within the boundary of the proposed SRS would remain after the life span of the facility.

4.2.4.2 No Action Alternative

If no action is taken to construct the proposed SRS site, there would be no effect upon minerals production conditions at the site.

4.2.4.3 Minimal SRS Infrastructure Alternative

The footprint of the disturbed area would be similar to the proposed action; therefore, impacts would be similar.

4.3 WATER RESOURCES

The proposed SRS would use approximately 115 acre-feet of water per year during the construction phase, approximately 31 acre-feet of treated water per year for domestic purposes during normal operations, and up to 1,100 acre-feet of treated water per year for cryogenics production and domestic (Subsection 2.1.6.7, beginning on page 66). Up to 12 acre-feet of groundwater is required annually to supply the number of cattle allowed on current grazing allotments. The options for the supply, treatment, and storage of water would differ under the various scenarios for the development of the SRS. However, all of the scenarios involve use of groundwater resources that would result in some measure of aquifer draw down. Additionally, construction activities would alter storm-water runoff patterns in the 100-year floodplain designated by the Corps of Engineers.

To determine the effects of the SRS operations on the Jornada Basin aquifer, the NMSU Civil, Agricultural, and Geotechnical Engineering Department and the NMSU Water Resources Research Institute performed a study that evaluated the impacts of the various pumping scenarios on the aquifer and the existing nearby wells (WRRI 1996). The study used a model constructed to represent the local geology and aquifer characteristics. An abbreviated version of the report is attached as Appendix F

4.3.1 SURFACE WATER RESOURCES

There are no perennial water sources on the Jornada in the area of the proposed SRS. Ephemeral water sources are stock tank excavations and areas where storm-water runoff collects in shallow pools in arroyo or floodplain drainages. The 100-year floodplain, as designated by the Corps of Engineers, represents areas where storm-water runoff temporarily pools in low areas, or which are subject to storm-water runoff sheet flow (Figure 17 on page 103).

Impacts to surface water resources within the SRS boundaries would consist of altering the surface water-flow patterns, with accompanying changes in the erosion patterns. Impacts to surface water resources outside the SRS boundaries would consist of an increased demand on water resources stored in Elephant Butte Reservoir.

A perceived area of concern for impacts to surface water under either the proposed action or minimal infrastructure alternative is the potential impact of hazardous/toxic materials on the Rio Grande. The

SRS would not impact surface water resources in the Rio Grande below Elephant Butte Dam. The RLV vehicles would use oxygen and hydrogen for propellants. Even in the event of a catastrophic accidental release of the entire storage capacity of both propellant components, these gases would not create a pollution hazard for the underlying aquifer, nor would they create pollution hazards that could migrate to the Rio Grande through storm-water runoff. They would quickly evaporate into the atmosphere and neither is an air pollutant. The normal substances used in SRS facility and vehicle maintenance (e.g. petroleum products, cleaning solvents, etc.) are currently being used at numerous locations such as ranches and businesses in the I-25 corridor. These would be stored in lesser quantities at the SRS and used under carefully controlled conditions.

4.3.1.1 Proposed Action

Under the proposed action, water would be required for construction, domestic consumption (lavatories, food preparation, drinking, fire fighting, etc.), and cryogenic fuel production. Approximately 1,100 acre-feet of water per year would be required in the production of cryogenic fuel. Approximately 31 acre-feet would be required for domestic purposes. In order to provide for losses in treatment, transportation, and domestic consumption contingencies, water rights for approximately 2,000 acre-feet of water appropriations would be acquired for SRS operations (Subsection 2.1.6.7, beginning on page 66). This acquisition would entail negotiations with prospective sellers and additional legal steps as required by New Mexico law, which are intended to ensure that existing water users are not adversely impacted.

Groundwater quality in the SRS area is not satisfactory for cryogenic fuel production. It also would require treatment to meet standards for human consumption (Subsection 3.2.2, beginning on page 104). The use of SRS groundwater resources would not be economical because of the degree of treatment necessary to reduce the total dissolved solids content to an acceptable level for cryogenic fuel production. Surface water from Elephant Butte Reservoir is of sufficient quality to permit economical cryogenic fuel production and would be required under the proposed action. Water from the reservoir would be transported to the SRS via the pipeline discussed in Subsection 2.1.6.7, beginning on page 66. If the water treatment plant is located at Elephant Butte Reservoir, the concentrate by-product of the reverse osmosis treatment would be reinjected into the Reservoir. Since the existing average total dissolved solids level of the water from the Reservoir, approximately 300 parts per million, is the same as the maximum acceptable level for cryogenic production (Subsection 3.2.1.1, beginning on page 99), the total dissolved solids of the reinjected concentrate typically would be less than 500 parts per million and would not exceed Safe Drinking Water Act standards. There are no State or local regulations covering return flow to the reservoir from reverse osmosis filtration under these conditions. If required, an NPDES permit would be obtained from the EPA for this process.

The approximate maximum water requirement of 2,000 acre-feet per year is 0.6% of the normal annual release of 323,600 acre-feet from Elephant Butte Reservoir and is approximately 1% of the lowest recorded release. This unusually low annual release occurred at a time when the reservoir was at one of the lowest storage levels on record (WRRI 1996). The SRS requirement also is considerably less that the annual loss to evaporation. Consequently, the use of Elephant Butte Reservoir as the source of water for the SRS would not constitute a significant impact on area surface water resources.

Base Floodplain

Portions of the proposed SRS are located within the 100-year floodplain designated by the U.S. Army Corps of Engineers, Albuquerque Engineer District, but are not in a portion of a floodplain designated as a special hazard area by the Federal Insurance Administration. The floodplain is depicted in Figure 17 on page 103. To the maximum extent practicable, placement of major SRS facilities outside the floodplain was a primary design criterion of the conceptual facilities in accordance with Executive Order 11988, May 24, 1977. The conceptual location and configuration of the facilities were based on

- Maximum use of existing WSMR-controlled special-use airspace, coupled with the general requirement to launch vehicles on easterly azimuths, dictated the placement of the operations area on the western side of the controlled airspace
- The logistics airfield area needed to be as far away from both flanking mountain ranges as possible, remain at the minimum safety distance from the operations area, and allow airfield operations to be conducted without overflight of the space vehicle operations area
- Maximum use of New Mexico State Trust Land
- Displace major facilities a maximum distance from the El Camino Real

As shown in Figure 17 on page 103, the "tree-branch" effect of the perpendicular branches of the central floodplain are pronounced east of the proposed location. Construction of facilities eastward of the designated floodplain branches is not possible due to proximity of the San Andres Mountains and the presence of multiple, deep arroyos in the foothills. As a result, the conceptual location of SRS facilities cannot be moved to the east without encroaching on the floodplain at some point. Since the factors discussed previously preclude further displacement west of the proposed location, there are no practicable alternatives to the proposed location.

The SRS has been designed to preserve, as well as enhance, the natural and beneficial floodplain values by minimizing construction in the floodplain. The airfield runway and apron areas would be constructed across a branch of the floodplain, affecting an area of approximately eight acres. In addition, the main access road and internal service roads would cross the floodplain at 10 places, affecting a total of 2.23 lineal miles of roadway. The relationship of the proposed SRS facilities to the floodplain is shown in Figure 30.

All conceptual SRS facilities and road infrastructure would be designed and constructed under the Best Available Technology standards and Best Management Practices standards for controlling storm-water runoff and flooding, including elevation of facilities above the base flood level and use of flood-related design features. Consequently, proposed SRS facilities would not only preserve adequate flow circulation but would improve free, natural drainage patterns. As a result, SRS construction would improve storm-water runoff patterns in the northern Jornada Draw floodplain. The improved runoff patterns would reduce erosion damage and foster improved vegetation patterns, thus providing a net beneficial effect.

State floodplain regulations are identified in Table 56 on page 316. Construction and maintenance activities would adhere to all pertinent regulations (Subsection 2.1.2.5, page 26). Construction would be performed under standard State of New Mexico contract provision. The State agency most likely to administer the construction contract will be the New Mexico

Figure 30. 100-year Floodplain in the Operations and Airfield Areas

State Highway and Transportation Department. The Highway Department is qualified in and uses Federal Highway Administration procedures and standards.

The location and construction of the logistics airfield in the floodplain would not constitute a risk to the structures or the floodplain, nor should it involve interruption of service or facility loss. The improvement in general flow patterns would further mitigate an already very low probability of loss of human life from flooding, and construction of the proposed SRS would not result in a notable adverse impact on natural and beneficial floodplain values. Consequently, the proposed SRS does not constitute a significant floodplain encroachment.

4.3.1.2 No Action Alternative

Without construction of the SRS, existing storm-water runoff and erosion patterns would continue without modification. Aerial photographs of the Jornada Draw floodplain show that sheet flow conditions have resulted in significant silt deposits over a broad area from northwest of Prisor Hill to southwest of Upham Hills. A line drawing from these photographs is shown in Figure 17, on page 103. Continued erosion from storm-water runoff eventually would result in the formation of a playa lake devoid of vegetation.

4.3.1.3 Minimal SRS Infrastructure Alternative

Under this alternative, cryogenic fuels would be produced off-site and transported to storage facilities at the SRS. The water pipeline from Elephant Butte Reservoir—with the associated soil disturbance and loss of habitat—would not be required. The estimated total water requirement for domestic purposes would be supplied through groundwater sources within the SRS area. Controlling storm-water runoff and flooding still would provide beneficial effects. The encroachment on the 100-year floodplain would not change. As discussed previously ("Base Floodplain" beginning on page 204), the construction under this alternative would not constitute a significant floodplain encroachment.

4.3.2 GROUNDWATER RESOURCES

The approximately 115 acre-feet per year of water needed during construction would be obtained from existing wells or by developing new wells in the central SRS area. The water for the initial access road construction from I-25 would be purchased directly from existing water resources in the Rincon area. After road construction has progressed beyond an economical hauling distance from the Rincon area, existing local wells would be enhanced or new wells developed to provide the road construction requirements, as well as to supply the initial operating requirements.

If the cryogenic fuel plant were to be constructed, the primary source of water would shift to surface water resources as discussed previously. However, groundwater assets would be developed and maintained for use in emergencies or during periods when extended drought conditions could have significant impacts on Elephant Butte Reservoir.

4.3.2.1 Proposed Action

The impacts of using groundwater resources exclusively for the operation of the SRS were modeled by NMSU (WRRI 1996). The model assumed the SRS would be constructed and operated according to the proposed action. A brief description of the modeling parameters and the general impacts provided by the model output for each of the alternatives are discussed below. A condensed version of the WRRI (1996) report is contained in Appendix F.

Model Description

Modeling was performed using the U.S. Geological Survey MODFLOW software package. Computations were performed for a 39-mile × 38-mile grid of 1-mile-square cells. These cells were selected to match the Public Land Surveying System's Range, Township, and Section grids, which were used to identify the individual cells.

The northern boundary of the grid started near the Socorro/Sierra County line at Township 12 South and extended south to Township 18 South, north of Rincon. The grid's east/west boundaries were established as the Caballo Mountains at Range 3 West and the San Andres Mountains at Range 4 East. The computer model boundaries were established using known and derived geological formations within the Basin. The east/west boundaries reflected predicted no-flow boundaries based on actual geologic formations, which are relatively impervious. Internal no-flow boundaries also were established to reflect the volcanic outcrops at Prisor Hill, Upham Hills, and Point of Rocks. The northern boundary is assumed to lie along a surface watershed divide as a bounding case for modeling purposes. The southern boundary was modeled as a constant depth-to-groundwater boundary using actual values from King et al. (1971). The boundary parameters in the vicinity of the SRS are shown in Figure 31.

The model draw-down results were based on hypothetical wells placed in three potential locations within the SRS area. Well No. 1 was centrally located within the proposed SRS and should therefore minimize the impact of pumping on neighboring wells. The location for Well No. 2 was seven miles north, very near the proposed SRS operations area. The location for Well No. 3 was farther east in order to examine the effect of moving the well field closer to the center of the basin.

Model runs were made to investigate the draw down that could be expected for various pumping rates, durations, and locations. Draw-down values were calculated by comparing groundwater levels with the initial groundwater levels after the duration of pumping. Pumping rates of 1,000, 1,500, 2,000, 3,000, and 4,000 acre-feet per year were considered. Pumping for periods of 5, 10, 20, and 50 years were modeled. Appendix F contains tables that provide the estimated draw-down values for each pumping scenario for the three hypothetical locations. These tables show the predicted maximum draw down at the well location and along the northern and southern boundaries of the SRS. Appendix F also shows the draw-down contours produced by the model for each of the representative scenarios.

Summary of Impacts of the Proposed Action

Subsection 3.2.2, beginning on page 104, discusses the existing private wells located closest to the SRS borders. To avoid adverse effects to these existing wells, a theoretical maximum draw down of 20 feet at the SRS boundaries would be considered acceptable. There is insufficient information to provide a credible estimate of the cumulative draw down or to project the life of the aquifer. Beginning on page 175 is an unnumbered subsection discussing of the use of incomplete or unavailable information.

Figure 31. Groundwater Model Parameters

The model data provides the following results:

- for Location No. 1, the acceptable pumping rate is 2,000 acre-feet per year
- for Location No. 2, the acceptable pumping rate is less than 1,000 acre-feet per year
- for Location No. 3, the acceptable pumping rate is 1,500 acre-feet per year
- the northern boundary draw down is much greater for all three locations
- the southern SRS boundary allows pumping rates of up to 4,000 acre-feet per year

Table 35 provides modeling results for the scenarios under the proposed action.

Table 35. Summary of Maximum Draw Down for Pumping at 2,000 Acre-Feet

Well Location	Duration of Pumping (years)	Maximum Draw Down (in feet)		
		At Well Field	At North Boundary	At South Boundary
Well Location No. 1	5	30.6	10.7	5.9
	10	32.6	15.1	6.6
	20	33.9	18.3	7.0
	50	34.3	19.2	7.1
Well Location No. 2	5	41.2	26.5	3.3
	10	48.2	35.2	4.4
	20	53.2	41.6	5.2
	50	54.8	43.6	5.4
Well Location No. 3	5	33.7	17.2	3.6
	10	37.5	23.4	4.4
	20	40.3	27.8	5.0
	50	41.1	29.1	5.2

Data Source: WRRI 1996

Currently, approximately 12 acre-feet of water is required to sustain the maximum cattle allotments of 2,520 head of cattle for the SRS area. The establishment of the SRS exclusive use area would reduce the allotments to 2,340 head of cattle. The reduction in grazing allotments would decrease water requirements for cattle to approximately 11 acre-feet per year. Pumping this quantity of water would not have a significant impact on groundwater resources.

4.3.2.2 No Action Alternative

Under this alternative, the cattle allotments and the associated water requirements would not change.

4.3.2.3 Minimal SRS Infrastructure Alternative

Under this alternative, cryogenic propellants would be produced off-site and transported to storage facilities in the SRS. Consequently, the estimated total water requirement for domestic purposes would be supplied through groundwater sources within the SRS area. These requirements consist of 115 acre-feet per year during construction, 31 acre-feet per year for SRS domestic purposes, and 11 acre-feet per year for cattle. The well capacity developed for construction would continue to satisfy the requirements for operation of the SRS.

Water purification to supply potable water would be accomplished using small individual reverse osmosis units. The concentrate produced by this process would be used for nonpotable domestic purposes, such as launch/landing complex deluge systems, fire-fighting reserve storage, and for dust control on unpaved roads.

4.4 AIR QUALITY

Construction and operation of the proposed SRS would result in the release of certain contaminants into the air. These emissions would consist almost entirely of criteria pollutants (particulates, sulfur oxides, carbon monoxide, hydrocarbons, and nitrogen oxides). Toxic emissions would be either very small or immeasurable.

4.4.1 CONSTRUCTION

The most important sources of air contaminants during construction of the SRS would include

- fugitive dust emissions resulting from site preparation, wind erosion, and vehicle travel on unsurfaced roads
- engine emissions from construction equipment
- organic vapors and other gaseous emissions from paving materials, paints, and coatings

4.4.1.1 Proposed Action

Assumptions

Air quality analyses were based on conservative assumption that 50,000 square feet of floor space would be constructed and 1,110 acres would be cleared and graded. Tables 4 and 5, on pages 49 and 58, provide a breakdown of the disturbed areas. Much of the road construction would consist of upgrading existing dirt roads. The duration of the construction project would be approximately 42 months. The engineering estimate is that approximately 2.7 million cubic yards of material would have to be hauled, and approximately 30 acres would be required for gravel and borrow pits.

Assumptions were made in estimating the air quality effects of the construction phase of the project. These assumptions are

- Construction and improvement of the roads would take place at a constant rate during the first 24 months of the construction phase. Most roadbed preparation would take place during the initial 18 months and most paving would take place during the following 6 months.
- Ninety-five percent (95%) of the roads would be hard-surfaced with asphaltic concrete and the remainder would be compacted gravel. The pavement layer would be 2 inches thick.
- Two scrapers, two bulldozers, two loaders, 10 trucks (dump trucks and water trucks), two compactors, and 6 other assorted pieces of equipment would be required throughout the first 18 months of road construction. A paving machine would replace the scrapers and bulldozers during the final 6 months.
- Work would take place ten hours per day, five days per week.
- Buildings, including site and pad preparation, would be constructed at a constant rate throughout the construction phase. Site preparation would require one bulldozer, one loader/backhoe, two trucks, one drilling machine, and one compactor used for 10% of the construction time. Building erection would require two cranes, two forklifts, two trucks, one compressor, and one generator.
- Airfield and rail spur construction would take place during the final 24 months of the construction phase. Equipment requirements would be the same for road construction.
- Any area of disturbed ground surface, except gravel and borrow pits, would be susceptible to severe wind erosion for approximately three months because as work progresses the surface is covered.

- Watering and other control methods would reduce the quantity of fugitive dust emitted by 90%. This is a conservative assumption. An effective dust control program can nearly eliminate emissions.
- One-hundred thousand (100,000) square feet of interior wall space would be painted, but 80,000 square feet would be done with water-based paints that emit no air contaminants. For the remaining 20,000 square feet, two coats would be required, with each gallon covering 500 square feet. The volatile organic material in the paint would be 5 pounds per gallon.

Emission Estimates

Emission factors that can be used to estimate the air contaminant release resulting from construction projects have been developed by the EPA (EPA 1992). Fugitive dust from soil-disturbing activities results in the most uncertain estimate of all construction-related air contaminants. The quantity depends on soil composition, which can vary widely across a construction site. Table 9, on page 93, shows the characteristic of the soils at the proposed SRS. Fugitive dust also depends strongly on the moisture content of the soil. A well-designed dust control program (watering and/or using chemical control agents) would virtually eliminate fugitive dust. Conditions would be monitored carefully and additional moisture control applied when necessary. Standard EPA emission factors for fugitive dust from construction sites are based on monthly emissions per acre (EPA 1992). These factors were used in the analysis. Fugitive dust released by wind erosion of disturbed ground surfaces is implicitly included in the EPA emission factor for construction activity.

Emission factors and duty cycles developed by the EPA (EPA 1992) were used to estimate the engine emissions of construction equipment. Air emissions that would result from the construction phase of the proposed SRS are summarized in Table 36. This table assumes 90% effective dust control measures, well within capability at a well-managed construction project. The regulated component of fugitive dust, PM_{10} (particulate matter diameters less than or equal to 10 micrometers), is reported in the table.

Table 36. Estimated Emission of Criteria Air Pollutants That Would Result from the Construction Phase of the Proposed Action

	PM_{10} emissions (tons)	SO_x emissions (tons)	CO emissions (tons)	NO_x emissions (tons)	Hydrocarbon emissions (tons)
Road, airfield, rail roadbed preparation (vehicle engine emissions)	12	17	65	157	14
Road, airfield, rail roadbed preparation (fugitive dust)	276				
Paving equipment	1.5	2.6	10	24	1.9
Paving (asphalt emissions)					10.8
Building site preparation (engine emissions)	0.5	0.8	3.2	7.8	0.6
Building site preparation (fugitive dust)	3.8				
Building and plant erection	3.0	4.0	14	39	3.4
Building and plant erection (fugitive dust)	34				
Paint and coatings					0.2
Total	330.8	24.4	92.2	227.8	30.9

PM_{10} — particulate matter
SO_x — sulfur oxides
CO — carbon monoxide
NO_x — nitrogen oxides

These contaminants would be released over a 42-month period and over a substantial area. The contaminants released by construction of roads and transportation facilities would be released over a period of approximately 24 months and over more than 50 lineal miles of road. At any one point, construction activity might require as little as 2 months. It is estimated, for example, that the daily release of PM_{10} particulate matter in each 100 feet of road would be no more than 2 pounds. This would correspond to a volume of about 21 cubic inches, or about 1½ cups.

In order to investigate the airborne concentration of contaminants, the EPA highway dispersion model HIWAY-2 (EPA 1980) was used to predict the concentration of contaminants along sections of road under construction. Prevailing wind conditions from Table 11, on page 110, were assumed, and the predictions were made for 24-hour averages for points 100 feet from the road. The results are shown in Table 37 along with national and New Mexico air quality standards. All predicted contaminant concentrations are far below ambient air quality standards. If effective dust control were not implemented, PM_{10} levels could exceed the standard near the construction zone. Release of construction-related air contaminants would cease upon completion of the construction phase of the project. Overall, construction under the proposed action would have minimal impact on air quality.

Particulate matter has the potential to approach the level of national and New Mexico air quality standards only if effective dust control is not used.

Table 37. Predicted Concentrations of Criteria Air Pollutants Released by Construction Activities

Twenty-four-hour average concentrations were predicted for points 100 feet from the construction area. National and New Mexico Ambient Air Quality Standards are included for comparison.

Pollutant	NAAQS	NMAAQS	Predicted Concentration	Predicted Concentration without Dust Control
Particulate matter	50 $\mu g/m^3$	60 $\mu g/m^3$	15.3 $\mu g/m^3$	153 $\mu g/m^3$
Sulfur oxides	0.14 ppm	0.10 ppm	0.004 ppm	0.004 ppm
Carbon monoxide	9.0 ppm	8.7 ppm	0.003 ppm	0.003 ppm
Nitrogen oxides	-a-	0.10 ppm	0.007 ppm	0.007 ppm
Ozone	0.12 ppm[b]	0.06 ppm	-c-	-c-
Hydrocarbons	-d-	-d-	0.001	0.001
Lead	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	-e-	-e-

Notes
- a There is only an annual national standard for NO_x.
- b Standard is for one-hour average.
- c Ozone is not directly released. Conditions would not lead to a measurable ozone increase.
- d Hydrocarbons are an ozone precursor, but are not a Criteria Pollutant.
- e There would be no lead emissions.

$\mu g/m^3$ — micrograms per cubic meter
ppm — parts per million

4.4.1.2 No Action Alternative

Under this alternative, the SRS would not be developed. There would be no construction-related air emissions. Fugitive dust, however, would continue to result from wind erosion and vehicle travel.

4.4.1.3 Minimal SRS Infrastructure Alternative

Under this alternative, temporary structures, such as office trailers, would be used instead of site-built structures. Construction activity would be limited to site leveling and building simple supports to position temporary structures. Some of the interior roads would not be paved. Less dust would be released by road construction. However, use of those same roads to haul materials to other construction sites would release dust. The cryogenic fuel plant would not be constructed, thereby eliminating air contaminants associated with its construction. Some emissions, however, would increase. For example, providing a given amount of office space in temporary structures would lead to disturbance of a greater land area than construction of the same amount of space in permanent buildings. On balance, it is likely that air quality effects of the construction phase of this alternative would be comparable to effects under the proposed action.

4.4.2 OPERATIONS

Elements of the SRS that would lead to emission of gases and/or particulates into the air include

- launch operations
- operation of the cryogenic fuel plant
- vehicle, rail, and air transportation
- maintenance operations
- space heating and cooling and water heating

Where appropriate, these are examined separately.

4.4.2.1 Proposed Action

The following discussion analyzes the impacts of anticipated emissions of nitrogen oxides, water vapor, and fugitive dust.

Launch Operations

Water Vapor and Nitrogen Oxides

Vehicles that would be launched from the proposed SRS would be fueled with liquid hydrogen and liquid oxygen. The only combustion product from these propellants is ordinary water in the form of superheated steam. Depending on ambient temperature and relative humidity, the steam rapidly cools to form either invisible water vapor or a visible cloud of condensed water droplets. Water is naturally abundant in the lower atmosphere and is not considered a pollutant.

The scientific literature includes a number of reports concerning production of nitrogen oxides within plumes of rocket motors. Formation of these gases is important because they contribute to ozone depletion in the stratosphere. Although significant quantities of these gases are produced by solid rocket motors, only small quantities would be produced by the hydrogen/oxygen engines that would be used for launching RLVs from the SRS (Stewart and Gomberg 1976, Gomberg and Stewart 1976, DOE 1980a, DOE 1980b). A solid rocket exhaust plume contains a significant concentration of carbon monoxide that burns after mixing with air. Nitrogen oxides are formed in this afterburning process. In the plume of a hydrogen/oxygen engine, combustion is complete and the amount of nitrogen oxides produced is much smaller. Nitrogen oxides also may be produced in the hot gaseous region that surrounds a space vehicle as it reenters the atmosphere. This process takes place only at high altitude and would not directly affect the SRS area. In addition, chlorine released by solid rocket motors is a serious concern for its ozone depleting potential and is the subject of considerable scientific research (Space News 1995). Launching satellites with a hydrogen/oxygen-fueled RLV rather than solid-fueled vehicles—such as the Titan III, Titan IV, Space Shuttle, and Ariane 5—has the potential to significantly reduce the amount of ozone-depleting exhaust products released into the atmosphere.

A very large launch vehicle, the first stage of which was to be fueled with liquid methane/liquid oxygen and the second stage with liquid hydrogen/liquid oxygen, was under consideration for development in 1980. An analysis concluded that the effect of 400 missions per year (launch and reentry) would result in a less than 1% increase in the stratospheric concentration of nitric oxide (DOE 1980b). A maximum launch rate of only 35 launches per year is projected for the SRS; therefore, the effects of operations from the SRS would not significantly increase ozone depletion.

Release of water vapor in the ionosphere by rocket launches is known to affect the concentration of charged particles (DOE 1980a). The primary effect is change in the electromagnetic (radiowave) propagation properties of the atmosphere, which persists for only 4–6 hours along the launch trajectory. There are no known serious adverse effects of this phenomenon at the current world-wide rate of space launches.

Hypergolic Fuels

It is anticipated that vehicles to be launched from the SRS would be commercial derivatives of the X-33 vehicle currently being developed under a NASA contract. One of the requirements of the X-33 program is that the vehicle must not use hypergolic materials (materials that ignite on contact) to fuel attitude control thrusters. Commercial derivatives of the X-33 would use similar nonhypergolic thruster technology. Hypergolic fuels generally are hazardous chemicals. The primary purpose for eliminating hazardous fuels is to simplify maintenance and reduce the costs of operating the vehicle. It has the added benefit of making the air (and space) emissions of the thrusters benign. Thus, there would be no impact associated with hypergolic fuels.

Fugitive Dust

Engine blast potentially could raise a fugitive dust cloud during launch and vertical landing. Launch and vertical landing operations would be conducted from specially prepared 300- × 300-foot concrete pads. These pads would include blast diverters designed to protect the vehicle and nearby infrastructure from heat and blast effects. Additionally, pads would be flooded with water to provide additional thermal protection. It is unlikely that measurable quantities of dust would result from normal launch and landing operations.

Launch Summary

In summary, the air quality effects of launches from the proposed SRS would be minimal. The only exhaust product, water vapor, is not considered an air pollutant.

Operation of the Cryogenic Fuel Plant

The cryogenic fuel plant would be operated with a combination of electrically-driven compressors and a combustion-driven boiler. Electrically-driven equipment would not result in any local air pollution.

The primary air emissions from the cryogenic fuel plant would be carbon dioxide and nitrogen oxides. These gases would be emitted predominantly as a result of production of gaseous hydrogen. Data from operating plants indicate that a well-designed hydrogen production facility emits no more than 50 milligrams of nitrogen oxides per cubic meter of gaseous hydrogen (Johansen et al. 1992). At the capacity of the cryogenic fuel plant for the proposed SRS (sufficient to support two launches per week), this would result in a release of 14.6 tons per year of nitrogen oxides. This emission rate is less than half the 40-ton per year rate that would require the facility to obtain a New Mexico Prevention of Significant Deterioration Permit under New Mexico Air Quality Control Regulation 707. Dispersion modeling using SCREEN (EPA 1991) indicates that concentrations would be much less than the national and New Mexico air quality standards. Emissions of carbon monoxide and hydrocarbons each would be less than 10 tons per year, and emissions of sulfur oxides would be less than one (1) ton (Johansen et al. 1992). The Prevention of Significant Deterioration permit levels for these contaminants are 100, 40, and 40 tons per year respectively. During design of the plant, consultation would occur with NMED concerning permit requirements. Any required permits would be obtained in accordance with NMED Air Quality Division regulations and procedures.

Although carbon dioxide is not a regulated air pollutant, increased levels in the atmosphere are thought by many atmospheric scientists to contribute to gradual warming of the global climate. Operation of the cryogenic fuel plant would release carbon dioxide at a rate of up to 394 tons per day. Carbon dioxide mixes rapidly in the atmosphere to reach a rather uniform world-wide concentration with seasonal variation as a result of the uptake by plants during the growing season. It produces no known direct adverse human health effects at current and foreseeable atmospheric concentrations.

Vehicle, Rail, and Air Transportation

As many as 500 people ultimately may be employed at the proposed SRS, including SRS employees, launch vehicle operator employees, and others. These people would commute daily to the SRS. Many would make regular trips by vehicle among the various facilities, buildings, and workplaces. In addition, vehicles would be used to haul large and small cargo around the facility. Certain cargo would be transported to the SRS via railroad and others by air.

An evaluation of the air emissions associated with vehicle, rail, and air transportation was made using conservative assumptions. These assumptions are

- An aggregate average of 500 vehicle trips with average length of 10 miles would be made per day by site employees within the SRS site. Ten of these trips would involve travel on unsurfaced service roads.
- An average of 10 deliveries would be received each week via tractor-trailer rig.
- An average of 10 deliveries would be received each day via medium-sized truck.
- An average of one delivery would be received each week via rail. The typical train would consist of two engines and 10 cars.
- An average of one cargo aircraft landing and subsequent takeoff would be made per week. An older model Boeing 747 was used as the proxy aircraft in computing the air emissions.
- Employees would commute to the SRS over an average round-trip distance of 80 miles with an average of two occupants per vehicle.
- Emissions associated with occasional helicopter landings and takeoffs and by a limited number of small aircraft were not calculated because such uses cannot be predicted. These emissions were considered to be inconsequential.

Using pollution emission rates developed by the EPA for vehicles, locomotives, and aircraft, and an EPA method to compute fugitive dust from unpaved roads, releases of air contaminants were calculated (EPA 1992). The results are shown in Table 38.

Table 38. Summary of Air Pollutants Released Annually at the Proposed SRS by Transportation-Related Sources

	PM_{10} Emissions (tons/year)	SO_x Emissions (tons/year)	CO Emissions (tons/year)	NO_x Emissions (tons/year)	Hydrocarbons Emissions (tons/year)
Light vehicles on-site	5.1	0.2	3.9	0.3	0.4
Medium and heavy trucks	0.03	0.06	0.6	0.4	0.1
Fuel handling & storage					0.6
Railroad	0.1	0.3	0.7	1.9	0.5
Cargo aircraft	0.02	0.04	1.0	0.5	0.4
Employee commuting	1.4	0.7	15.4	1.3	1.5
Total	6.7	1.3	21.6	4.4	3.5

PM_{10} – Particulate matter
SO_x – Sulfur oxides
CO – Carbon monoxide
NO_x – Nitrogen oxides

These quantities are far less than the comparable quantities that would be released by construction activities on the same roads. Because it is obvious that the concentrations would not exceed national and New Mexico standards, no dispersion modeling was performed.

An additional transportation-related air pollutant source would be emission of fuel vapors from on-site, above-ground storage facilities and from fuel delivery and dispensing operations. Using the earlier assumptions for the daily mileage, and assuming conservatively that all of the vehicles would be gasoline-fueled and the average fuel mileage would be 15 miles per gallon, the daily fuel consumption would average 333 gallons. A 2,000-gallon storage tank was assumed because it would provide a reasonable time between fuel deliveries, approximately one week. The assumption that all vehicles would be gasoline-fueled is conservative because diesel fuel is much less volatile and emits far less vapor than gasoline under similar storage and handling conditions. This emission sources also is included in Table 38.

EPA's *Compilation of Air Pollution Emission Factors* (EPA 1992) provides a methodology to estimate the standing and working losses from fuel storage and handling operations. Standing losses result from expansion and contraction of vapor in the tank, and working losses result from filling the tanks and dispensing fuel to vehicles. The estimated annual standing and working losses are 374 and 793 pounds respectively for a total of 1,167 pounds (0.58 ton), or the equivalent of less than 200 gallons of gasoline. Fuel vapor would be released at a rate of less than 5 pounds per day and would have no significant effects.

Maintenance of motorized vehicles would not produce significant quantities of air pollutants. Other than normal engine emissions during maintenance operations that require the engine to be running, emissions would be minimal.

Maintenance and Integration Operations

M&I procedures would result in release of minimal quantities of air contaminants. For example, certain hardware items such as valves, fittings, and hinges may require periodic cleaning, degreasing, lubrication, or coating. These processes would require small quantities of volatile chemicals and solvents. It is anticipated that requirements for these types of materials would be comparable to servicing a large aircraft. It is assumed 10 gallons (60 pounds) of solvents per month would be used. The usual safety precautions associated with these materials would be followed. Impacts associated with releases of small quantities of chemicals would be too small to be measured.

Space Heating and Cooling and Hot Water

There would be approximately 50,000 square feet of heated floor space in several major and minor buildings. Under the proposed action, these buildings would be heated with natural gas and possibly cooled with gas-fired absorption cooling units. In addition, domestic hot water would be provided with gas-fired heaters. Estimated average daily consumption of natural gas for domestic purposes is 100,000 cubic feet. Using EPA emission factors for commercial and residential natural gas combustion (EPA 1992), this would result in the annual release of approximately 36 pounds of PM_{10} material (particulate matter), 22 pounds of sulfur dioxide, 3,650 pounds of nitrogen oxides, 730 pounds of carbon monoxide, and 290 pounds of hydrocarbons including methane. These pollutants would be much smaller in quantity than those from the cryogenic fuel plant and much more widely dispersed. Therefore, dispersion modelling was not performed.

Miscellaneous Air Pollutants

Standby generators may be required to supply electrical power in the event of a power outage during a mission or at some other critical time. Standby generators would be tested periodically. It is estimated that total standby generation, including testing, would be no more than 10% of the level used in analyzing the impacts under the minimal infrastructure alternative (Subsection 4.4.2.3, beginning on page 225). Corresponding quantities of air pollutants were included in the air quality analysis.

Fire-fighting training may result in air emissions from periodic training fires. Training would be done in compliance with all applicable regulations including open burning regulations. Total annual emissions from this source would be negligible.

Summary of Nonlaunch Air Pollutants

Air pollutants released annually during the operational phase of the proposed action, and an estimate of the maximum concentration of each pollutant likely to occur within the SRS boundary, are summarized in Table 39. Concentration estimates were derived by applying the EPA air dispersion model SCREEN (EPA 1991) to emissions from the cryogenic fuel plant at a distance of 100 feet. For all pollutants, the fuel plant would be the most concentrated source. Although total annual emissions of carbon monoxide resulting from transportation sources would be larger than that from the fuel plant, it would be spread over a large area and so would result in a smaller average concentration. The results are very conservative because the SCREEN model predicts the highest concentration likely to occur with the given emission conditions under any meteorological conditions. In addition, the point chosen for prediction of the concentrations is only 100 feet from the largest stationary source of contaminants. At the boundary of the proposed SRS, the concentrations would be far lower.

Table 39. Estimated Annual Releases of Air Pollutants in Tons Under the Proposed Action

Also included is the maximum predicted 24-hour average concentration under worst-case meteorological conditions as determined with the EPA screen model.

	Transpor-tation	Space Heating	M&I	Cryogenic Fuel Plant	Standby Generators	Total	24-hour Average Ambient Air Quality Standard*	Predicted Concentration
Particulate matter	6.6	0.02		1	0.01	7.6	50 $\mu g/m^3$	0.49 $\mu g/m^3$
Sulfur dioxide	1.3	0.01		1	0.01	2.3	0.10 ppm	0.0002 ppm
Carbon monoxide	21.6	0.4		10	0.02	32.0	8.7 ppm	0.004 ppm
Nitrogen oxides	4.4	1.8		14.6	0.08	20.9	0.01 ppm	0.006 ppm
Ozone						-b-	0.06 ppm [a]	-b-
Hydrocarbons	2.9	0.1	0.4	1	0.002	4.4	-c-	0.001 ppm

Notes
* the smaller of National or New Mexico.
a Standard is for one-hour average.
b Ozone is not directly released. Conditions would not lead to a measurable ozone increase.
c Hydrocarbons are an ozone precursor but not a Criteria Pollutant.
$\mu g/m^3$ – micrograms per cubic meter
ppm – parts per million

As is evident from Table 39, emissions of air pollutants during the operational phase of the proposed action would not result in nonattainment of National or New Mexico Ambient Air Quality Standards for criteria pollutants. Emissions of toxic pollutants associated with the proposed SRS would be too small to be measured.

4.4.2.2 No Action Alternative

Under this alternative, the SRS would not be constructed. Although there would be no local release of air contaminants, current fugitive dust emissions would continue to occur.

4.4.2.3 Minimal SRS Infrastructure Alternative

Under this alternative, certain categories of air contaminants at the proposed SRS would be reduced, but others would be increased compared with the proposed action. Because the cryogenic fuel plant would not be constructed, there would be no emissions of carbon monoxide and nitrogen oxides associated with the facility. Instead, fuel would be produced at other locations and trucked to the SRS. Transport trucks needed to haul the fuel to the SRS would release quantities of contaminants along the transport route.

Most of the SRS road network would remain unpaved. Although the level of activity under this alternative would be lower than that of the proposed action, the quantity of PM_{10} material that would be released would be as high as 158 tons per year during the operational phase of the project. This estimate was obtained by assuming that none of the roads would be paved, and because there would be fewer facilities, vehicular traffic would occur at half the level described in the proposed action. To ensure a conservative estimate, it was further assumed that no dust-control program would be in effect. The resulting concentrations would be less than those from construction and so would not exceed ambient air quality standards.

Electrical power would be supplied by generators. Under the proposed action, the peak electrical power requirement (without the cryogenic fuel plant) is estimated to be 5 megawatts (MW). Most of the time, the power required would be considerably smaller. A facility of reduced size and scope would require a peak power level comparable with the proposed action. During nonpeak times, the power requirement would be much smaller so that the overall electrical energy requirements would be reduced. Assumptions used to estimate air emissions associated with generators are

- five (5) MW would be required during launch and recovery operations for 4 hours each week
- during the remainder of the 40-hour work week, 500 kilowatts (kW) (0.5 MW) would be required
- during nonworking hours, 50 kW would be require for security lighting, low-level activity, etc.

Using EPA emission factors for diesel generators (EPA 1992), the estimated annual air emissions would be 154 pounds of PM_{10} material, 175 pounds of sulfur dioxide, 401 pounds of carbon monoxide, 1,540 pounds of nitrogen oxides, and 45 pounds of hydrocarbons.

Summary of Air Emissions

Air emissions under this alternative are summarized in Table 40. All predicted concentrations are below national and New Mexico air quality standards.

Table 40. Estimated Annual Releases of Air Pollutants in Tons Under the Minimal SRS Infrastructure Alternative

Also included is the maximum predicted 24-hour average concentration under worst-case meteorological conditions as determined with the EPA screen model.

	Transpor-tation	Space Heating	M&I	Electrical Generators	Total	24-hour Average Ambient Air Quality Standard*	Predicted Concentration
Particulate matter	161	0.02		0.1	161.1	50 $\mu g/m^3$	8.8 $\mu g/m^3$
Sulfur dioxide	0.6	0.01		0.1	0.7	0.10 ppm	0.002 ppm
Carbon monoxide	10.8	0.4		0.2	11.4	8.7 ppm	0.002 ppm
Nitrogen oxides	2.2	1.8		0.8	4.8	0.01 ppm	0.004 ppm
Ozone					-b-	0.06 ppm [a]	-b-
Hydrocarbons	2.9	0.1	0.4	0.02	3.4	-c-	0.001 ppm

Notes
* the smaller of National or New Mexico
a Standard is for one-hour average.
b Ozone is not directly released. Conditions would not lead to a measurable ozone increase.
c Hydrocarbons are an ozone precursor but not a Criteria Pollutant.
$\mu g/m^3$ – micrograms per cubic meter
ppm – parts per million

4.5 BIOLOGICAL RESOURCES

This subsection defines the potential effects of the proposed construction and operation of the SRS on biological resources. The impacts discussed in the following paragraphs are virtually the same for the proposed action and the minimal infrastructure alternative.

4.5.1 PROPOSED ACTION

4.5.1.1 Vegetation Types

The construction of the proposed SRS facilities and connecting roads would result in transformation by clearing and grading approximately 1,110 acres of natural habitat. This represents 0.5% of the 398 acres of the proposed SRS. Only three vegetation types would be affected by construction—Chihuahuan broadleaf evergreen desert scrub (59 acres), Chihuahuan broadleaf deciduous desert scrub (1,046 acres), and Chihuahuan foothill-piedmont desert grassland (4 acres). Figure 19, on page 116, displays the areas of affected vegetation. The airfield would impact the greatest diversity of plant species and vegetation communities. Some amount of revegetation would be performed in disturbed areas.

4.5.1.2 Endangered, Threatened, or Sensitive Species of Plants

No Federally-listed plant species were found in areas potentially affected by construction of the proposed SRS facilities. Biological field surveys were initiated in August 1994. Four individual plants of Scheer's pincushion cactus (*Coryphantha scheeri* var. *valida*) and two of Wright's pincushion cactus (*Mammillaria wrightii* var. *wrightii*) were found in the proposed SRS project area. At the time of the surveys, both species were listed as State endangered species. In October 1995, both species were down-listed from the *State Endangered Species List* (List 1) to the *Plant Taxa Considered, But Not Included List* (List 4) (Sivinski and Lightfoot 1995); therefore, it is not required that they be avoided during construction of SRS facilities. None of the six plants were located in areas that might be impacted by proposed construction. Consequently, construction of proposed SRS facilities would not significantly impact the survival of these two species of cacti. If need be, NMSLO management plans would dictate how these species would be managed should the SRS be constructed.

4.5.1.3 Endangered or Threatened Species of Wildlife

No Federally-listed endangered or threatened species of wildlife were found in areas potentially affected by construction of proposed SRS facilities. Thus, no impact to Federally-listed animals would result from construction of proposed SRS facilities and roadways.

Candidate Species and Species of Concern

As noted in Subsection 3.5.2.2, beginning on page 120, four species classified as USFWS Candidate Species or Species of Concern and one State of New Mexico endangered species were found in areas potentially affected by construction of proposed SRS facilities. The Federally-listed species were the Western Burrowing Owl, the Ferruginous Hawk, the Loggerhead Shrike, and the Texas horned lizard. The New Mexico-listed species was the Bell's Vireo. Construction of proposed SRS facilities and connecting roadways does not appear to pose a substantial threat to any of the species above nor their nesting habitats (PSL 1996).

The Western Burrowing Owl, The Ferruginous Hawk, and the Bell's Vireo were observed only in areas where no proposed construction would take place. The Loggerhead Shrike was observed throughout the entire SRS area. This species is considered to have low sensitivity in the SRS area because of the large number of birds observed and the abundance of typical habitat. Although the Texas horned lizard is common throughout the desert areas of southern and central New Mexico, it was observed in small numbers in the SRS project area.

Some alteration and direct loss of wildlife habitat associated with construction activities could result in a minor loss of hunting, roosting, perching, foraging, and territorial display sites. This would be offset by the construction of raptor-electrocution-proof utility lines and use of Best Management Practices during construction activities.

Northern Aplomado Falcon

Although the Northern Aplomado Falcon is not known to nest on the proposed SRS area, and was not found during the two-year biological assessment, several areas in the vicinity exhibit ecological characteristics similar to potential critical habitat for the species. Ecological Services Field Office of the USFWS is currently updating recommended survey methodology for the Northern Aplomado Falcon in southern New Mexico (USFWS 1996a). This document would be used as a basis for future surveys in potential critical habitat areas for this species. A survey for the Northern Aplomado Falcon would be conducted during the nesting season prior to beginning construction activities at the SRS. A routine monitoring program would be an integral part of resource management plans implemented by the NMSLO (Subsection 4.8.2.1, beginning on page 258).

4.5.1.4 Raptors and Other Protected Bird Species

Depending upon the extent of land conversion and use, 41 large stick nests (23%) of the 179 documented in the area would be directly or indirectly impacted by construction, operations, or use of potential SRS facilities and connecting roadways. The nest locations are shown in Figure 20, on page 125. All nests were in good condition during the 1995–1996 biological surveys and available for use by small- to medium-sized raptors as well as other similarly sized birds, depending upon local environmental conditions.

Potential raptor nests within one mile of projected construction would be destroyed during the winter season preceding construction activities to preclude occupation during the subsequent nesting season. All above-ground electrical power lines would be constructed or modified using Raptor Research Foundation guidelines to prevent electrocution of raptors (RRF 1981).

4.5.1.5 Potential Impacts From Noise

A discussion of the anticipated extent and magnitude of noise from construction activities associated with the proposed SRS is presented in Subsection 4.7.1, beginning on page 242. Noise from operation of the proposed SRS is discussed in Subsection 4.7.2, beginning on page 245. The following discussion analyzes the potential effects of noise on wildlife communities in the affected area.

Background

The effects of noise on wild and domestic animals have been the subject of a large body of scientific research. Some of the pertinent results are discussed below.

Many studies have investigated the response of animals to sounds of varying intensity, duration, frequency, and direction. Ames and Arehart (1972) investigated the effects of intermittent bursts of white noise (simulated background noise), music, and miscellaneous sounds ranging in intensity from 75 to 100 dBA. This range encompasses the maximum intensities expected from construction and operational noise except launch noise, sonic booms, and noise within a small region surrounding the cryogenic fuel plant. This study and another by Borg (1981) demonstrated gradual habituation to intermittent sounds. Additional studies with wild animals show they do adjust to noise. These studies have been conducted with rodents by Borg (1979); with elk by Espmark and Langvatn (1985) and by Workman, et al. (1992); with mountain sheep and pronghorn by Krausman, et al. (1993) and by Workman, et al. (1992); and with desert mule deer by Krausman, et al. (1993).

Studies of the effects of aircraft noise have shown that wild and domestic animals initially respond to aircraft noise with a startle reaction. Pertinent studies were conducted by Bell (1972); Bond, et al. (1974); Espmark et al. (1974); Ewbank (1977); Cottereau (1978); Sinclair (1979); Manci, et al. (1988); Harrington and Veitch (1991); and Krausman, et al. (1993). Although ungulates have been known to stampede when exposed to loud noises (Gladwin et al. 1988), a study by Bunch and Workman (1993) demonstrated that elk, pronghorn, and Rocky Mountain bighorn sheep habituate rapidly and permanently to a wide range of noise disturbances. Test animals adjusted to subsonic and supersonic jet overflights typically after four passes. The animals did not adjust to people on foot or to low-level flights of fixed-wing aircraft and helicopters. Manci, et al. (1988) have reported that frequent loud noises can cause hearing loss in desert bighorn sheep, and Norrix, et al. (1995) have reported that this can increase their vulnerability to predation. Controlled experimental studies with sonic booms at levels up to 150 dB have failed to elicit panic responses in animals, but anecdotal accounts of panic behavior of flocks of certain birds has been given (Bowles 1995). Certain marine mammals have been observed to exhibit only mild and brief response when exposed to sonic pressure levels as high as 129.5 dB (Stewart 1993). Ellis, et al. (1991) reported that low-level jet aircraft and sonic booms, although they did elicit behavioral responses, did not cause reproductive failure in eight species of raptors studied.

A summary of the results of several studies of the effects of noise on animals demonstrated that exposure to noise at high levels of intensity and long duration, or frequent repetition for impulsive sounds, could cause measurable physiological effects (MSU 1971). The least significant effect observed was a temporary threshold shift in an animal's sensitivity to low intensity sounds that gradually returned to normal. The most significant effect observed was physical damage. The studies that reported physical damage were conducted on confined animals, and most of these were performed with at least 20 minutes of continuous exposure to a 500-hertz pure tone at an intensity of 128 dB. Wild animals could be expected to leave an area with continuous noise exposure long before the damage threshold would be reached. Another study demonstrated that wild mammals prefer nest sites away from noise sources. It also has been demonstrated that a sound level of at least 85 dB at a bird's ear usually is required to repel birds. Many studies failed to detect observable effects of noise on mammal and bird behavior near airports and military training areas.

Effects of Construction Noise

The analysis of construction noise given in Subsection 4.7.1, beginning on page 242, demonstrates that the noise level associated with construction would be temporary at any given location. The noise levels would be expected to be higher than 95 dBA within 50 feet and 85 dBA within 160 feet of an active construction site. Based on the studies cited above, animals within a maximum of 1,500 acres (0.6%) of the proposed SRS might be temporarily affected; however, most affected animals would be expected to temporarily leave the area. It could be expected that behavior of nesting birds might be temporarily disrupted within 160 feet of a construction area. Adverse impacts on nesting raptors or other sensitive species would be mitigated by destruction of potential nest sites as discussed in Subsection 4.5.1.4, beginning on page 229.

Effects of Operational Noise

Wildlife within 150 feet of the cryogenic fuel plant would be exposed to noise levels above 85 dBA. Animals beyond 150 feet would be exposed to levels of 85 dBA and lower. At 600 feet from the plant, the maximum expected noise level would be 73 dBA. From the results of published studies (MSU 1971; Borg 1981; Espmark and Langvatn 1985; Workman et al. 1992; Krausman et al. 1993), it is expected that animals outside the 85-dBA area would habituate to the noise, and animals within the 85-dBA area would either habituate or leave the area. Because the 85-dBA area would represent only 0.01% of the proposed SRS, effects of the fuel plant on wildlife would be minimal.

Animals within 500 feet of the airfield could be exposed to noise levels as high as 100 dBA during aircraft operations. Except for the final approach or climb-out phases of the flight, aircraft operations would not be expected to have major detrimental effects on wildlife. Animals within 50 feet of roads would be subjected to noise levels higher than 68 dBA each time a vehicle passed. It is unlikely that noise at this level would have significant detrimental effects.

Launch noise would be infrequent and of short duration. Prelaunch activity likely would cause birds and larger mammals to depart from the immediate area prior to launch. Small animals living in the ground would be largely protected by their burrows. Exposure to levels greater than 115 dBA would occur only within the boundary of the SRS. Exposure to noise during launch would be of relatively short duration. Based on the work of Ellis et al. (1991), raptors at the proposed SRS, except perhaps those in the immediate vicinity of the launch/landing complex, would not be expected to exhibit reproductive failure. Nesting in the immediate vicinity of the launch facilities would be discouraged by the proposed action of destroying nests located near the prospective SRS facilities. Therefore, no significant detrimental effects on wildlife within and near the proposed SRS would be expected from launch noise.

An additional wildlife noise issue is the potential effect of launch and sonic-boom noise on the population of desert bighorn sheep in the San Andres National Wildlife Refuge. Personal communication with the manager of the USFWS San Andres National Wildlife Refuge indicates that desert bighorn sheep are located on and in all points between Black Mountain, Bennett Mountain, San Andres Mountain, and Strawberry Mountain. At the point of closest approach, this area is over 20 miles from the launch site. Flight over the refuge, should it occur, would take place at high altitude and would result in an expected launch noise level of less than 100 dBA. Launch noise would occur for a duration of less than five minutes and at most once per week. Bunch and Workman (1993) observed the effects of aircraft noise, including sonic booms, on a number of ungulate species. They observed rapid habituation to all but low-level flight noise. Based on their work, no detrimental effects on the sheep would be expected. During launch, the animals in the refuge could be subjected occasionally to sonic boom overpressures in the range from 1 pound to 3 pounds per square foot, which corresponds to 132 to 137 dB. Nearby lightning strikes can produce thunder that reaches comparable overpressures. Bunch and Workman (1993) also have documented that Rocky Mountain bighorn sheep, a different subspecies, acclimate to sonic booms permanently and very quickly. Therefore, detrimental effects on the desert bighorn sheep in the San Andres National Wildlife Refuge would not be expected. There are no other species of special interest located on the San Andres National Wildlife Refuge.

4.5.1.6 Biological Diversity

Habitat surrounding the proposed SCCF, the airfield, and the launch/landing complex harbors the greatest diversity of plant species in the area. In addition, the airfield and the adjoining operations area are influenced by the 100-year floodplain, as designated by the Corps of Engineers.

Proposed SRS construction and operational activities in these areas would alter the natural species composition of the birds in the immediate vicinity of the nesting habitat. This alteration also could affect the potential raptor prey base. Similarly, increased visual, noise, and human disturbance likely would adversely affect aspects of the behavior, reproduction, and individual survival of nesting species. Adverse impacts could include disruption of foraging, site tenacity, breeding behavior and reproductive effort; nest abandonment; and increased individual mortality. These effects could result from an increase in hunting, vehicular mortality (i.e., roadkill), airplane and power-line collisions, and electrocutions. However, given the low density of nesting raptors and other sensitive species within 100 meters of the proposed facilities, it is likely that overall effects would be minimal (Skaggs 1995).

Construction Impacts

The construction impacts to all species of birds would be limited to the immediate vicinity of construction on the main access road, SCCF, operations, airfield areas, and utility lines. Construction of the main access road would have minor localized impacts. Construction of the SCCF area would have minor impact on the Jornada Draw 100-year floodplain because the SCCF facilities would be located more then 3 miles from the floodplain. Affected wildlife in the vicinity of construction of the operations and airfield areas would be absorbed within other portions of the SRS area.

Main access road construction activities in the vicinity of Exit 32 on I-25 would have no impacts to the Rio Grande flyway because roosting of en route birds occurs only along the river and adjacent farmland at least 2–3 miles from any planned construction. Biological richness in the Rincon Draw 100-year floodplain, located to the west of the main access road (Figure 17, on page 103), is less than that of the Jornada Draw floodplain. Construction activities would have minimal impacts to this area.

Construction in the operations and airfield areas would directly affect less than 1% of the Jornada Draw floodplain (Figure 17, on page 103). Approximately 12% of the construction activity would be within 1 mile of the floodplain, which could be affected indirectly. Impacts to the biological diversity of the area would be reduced because of the capacity of the area to absorb displaced wildlife into surrounding areas, i.e. arroyo habitat present in Jornada Draw, Flat Lake, Point of Rocks, etc. Using the average densities observed during bird surveys (Subsection 3.5.3.3, beginning on page 123), construction and operation of the SRS facilities would affect only an estimated 750 individual birds. Consequently, the capacity of the Rio Grande flyway would not be degraded through the absorption of any displaced neotropical migratory birds (NMSLO, pers. comm., 1996).

Operations Impacts

Insignificant and highly localized impacts to biological diversity from sustained SRS operations would result from noise, industrial activity, and space vehicle operations. In addition, certain accident scenarios could result in reduction of biodiversity.

Noise impacts to sensitive species were discussed previously in this section. Temporary biological diversity impacts from SRS operational noise could occur to neotropical migratory species of birds and nonsensitive wildlife species. These impacts, however, would be reduced to insignificance because affected animals would disperse into the surrounding area.

Industrial activity of the SRS area would result in the general impacts discussed previously in this section. The magnitude and severity of these impacts would be reduced through the application of the mitigation measures discussed and listed in Section 5.0, beginning on page 306. Plans for managing and monitoring the environmental effects of SRS operations on the area—including those on bird species protected by the Migratory Bird Treaty Act—would be developed and implemented by the NMSLO in accordance with State laws and regulations. Subsection 4.8.2.1, beginning on page 258, contains a discussion of wildlife and habitat management plan development by NMSLO. The NMSLO would seek input and consultation from Federal and State regulatory and resource management agencies.

Effects of space vehicle operations, other than noise, would be comparable to those of a commercial airfield. As discussed in Subsection 4.1, beginning on page 177, the design of the RLVs to be operated from the SRS would incorporate a safe abort capability and would utilize propulsion fuels that have a low potential for producing a catastrophic explosion in the event of a significant vehicle or industrial accident. The safe distance (quantity-distance) for a fully fueled vehicle on the launch pad, or for the cryogenic fuel plant with fully charged storage tanks, is 3,675 feet (Subsection 4.1.1.2, beginning on page 178). This distance is necessary to protect an unsheltered human from fatal injury from flying debris. The probability of injury or death to wildlife within this distance is comparable to that for an exposed person.

A random wildfire is the most significant threat to biological diversity and wildlife. A major wildfire could originate from natural causes, a space vehicle accident, a cryogenic fuel plant accident, or human carelessness. The SRS concept of operations includes a full-time fire-fighting capability that would be used to suppress any fire outbreak within the exclusive-use area, any structural fire within the SRS boundaries, or any wildfire constituting a threat to SRS or private facilities. Fires resulting from space vehicle accidents or naturally occurring wildfires outside of the exclusive-use area would be attacked at the point of origin, and suppression activities would be conducted according to applicable wildfire management policies and procedures promulgated by the NMSLO and BLM.

An effect of increased traffic would be roadkill of animals. Compared with major Federal and State highways in the area, the speed and volume of traffic on the SRS access and internal roads would be lower, and hence the number of roadkilled animals would be much smaller. It is unlikely that roadkill would have a significant effect on species of concern or on biological diversity.

4.5.2 NO ACTION ALTERNATIVE

The proposed SRS would not be constructed nor operated under this alternative. There would be no adverse effects on biological resources.

4.5.3 MINIMAL SRS INFRASTRUCTURE ALTERNATIVE

Under this alternative, impacts on plant and animal habitat would increase slightly. Some temporary structures (e.g., the SCCF) would disturb a larger land area than under the proposed action. Also, if most roads are left unpaved, increased fugitive dust would adversely affect roadside vegetation.

4.6 CULTURAL RESOURCES

Early Native American occupation, El Camino Real, early ranching activities, and one of the first railroads in New Mexico have left evidence of sites that potentially are eligible candidates for nomination to the National Register of Historic Places or the State Register of Cultural Properties. In addition, it was determined that under Eligibility Criterion (d), all 125 sites found during the Class III survey potentially are eligible for nomination to the National Register. The land management agencies, BLM and the NMSLO, would review each site's eligibility. If it is not possible to determine a site's eligibility from the survey data, test excavations would be conducted to obtain additional data to determine if the site is eligible. In accordance with Section 106 of the National Historic Preservation Act, six steps must be accomplished in order to correctly evaluate impacts of the proposed action for the SRS

- Identify the historic properties that may be affected by the proposed action.
- Determine the effects of the undertaking on properties identified.
- Consult among the Federal agencies, State Historic Preservation Officer, and others to seek ways to mitigate potential effects on historic and archaeological properties.
- Allow the Advisory Council on Historic Preservation a reasonable time to comment on the undertaking.
- Develop Memoranda of Agreement as appropriate.
- Proceed with the agency's decision-making process.

Potential impacts of the proposed action and the alternatives for SRS are discussed in terms of these five points in the following subsections.

4.6.1 PROPOSED ACTION

To satisfy Section 106 of the National Historic Preservation Act, cultural resource surveys were conducted in proposed construction and operational areas. These surveys were conducted during 1995–1996. A Class I survey of available records and reports found 749 sites previously identified as potentially eligible for nomination to the State Register of Cultural Properties (Subsection 3.6.5.1, beginning on page 132). One hundred twenty five (125) sites have been identified during Class III surveys performed as described in Subsection 3.6.5.2, beginning on page 134. These sites potentially are eligible for nomination to the Register as described in Subsection 3.6.7, beginning on page 134. Details of the characteristics of these sites are shown in Appendix E. The recommendations for mitigation also are shown in Appendix E. These options for mitigation are

- avoid
- monitor
- test
- recover data

According to the conceptual design of the SRS facilities and infrastructure (Figures 9 and 10, pages 48 and 57), approximately 54 archaeological sites would be directly impacted by the proposed action. These sites are identified in Appendix E with recommendations for mitigation that include testing for eligibility or data recovery for the entire site or for the right-of-way portion of construction passing through the eligible site. In Appendix E, 21 entire sites are recommended for testing or data recovery. The right-of-way portion directly affected by construction of roads and lineal facilities for the additional 33 sites is recommended for testing or data recovery.

The following mitigation options would be implemented after consultation with the appropriate agencies:

- Whenever possible, the SRS facilities, roads, and rights-of-way would be situated to avoid archaeological sites.
- Archaeological sites would be protected by fencing or other appropriate means.
- If archaeological sites cannot be avoided, a determination of eligibility to the National Register of Historic Places would be made by the BLM or the NMSLO in consultation with the State Historic Preservation Officer. Guidance from the Preservation Officer would be used to prepare a specific mitigation action plan for each eligible site.
- The Mescalero Apache Tribe in Mescalero, New Mexico, has been consulted to determine the presence of Traditional Cultural Properties and sacred sites in compliance with the American Indian Religious Freedom Act and the Native American Graves Protection and Repatriation Act. The Mescalero Apaches did not identify sacred sites with the proposed SRS boundaries. A record of consultations with officials of the tribe is included in Appendix B. Notification of

all other Native American tribal and pueblo officials in New Mexico has been accomplished by direct mailing, based on the list of officials provided by the NM Office of Indian Affairs.

- If cultural resources were uncovered during excavation, work would be stopped until a qualified archaeologist assessed the artifact. If the archaeologist determines that the resource is significant, the appropriate regulatory agency would be notified.
- Facilities would be sited and operations would be planned to minimize visual and noise impacts of SRS activities on El Camino Real.

El Camino Real is an issue of special concern. The access road and the water pipeline to the SRS would cross the trail near Upham and at Aleman. These sites were chosen for crossings because existing road rights-of-way can be used. In these places, El Camino Real has been extensively disturbed by long-term human occupation and by natural forces such as water erosion. Other construction proposed for the SRS would not physically alter the trail. Mitigation measures such as fencing and construction inspections would be employed to protect the trail and to ensure that construction equipment would not deviate from the proposed roadbed and pipeline rights-of-way. Mitigation measures for the SRS will be negotiated and consultation with the SHPO will be completed prior to issuance of the Record of Decision.

Specific mitigation measures would be included in the Programmatic Memorandum of Agreement to be negotiated as a part of Section 106 consultations associated with the transfer of public lands between NMSLO and BLM.

Operations such as spacecraft launches and the operation of the airfield also are issues of special concern. These would have potential visual and noise impacts on El Camino Real, as discussed elsewhere in the document. Visits to El Camino Real would be temporarily restricted during space vehicle launches and landings. The facilities would be designed to minimize visual impacts by using color schemes and architectural styles to blend with the surroundings.

Another issue is the concern for sites considered sacred by the Apache. Only one potential Apache site was found during the archaeological surveys. However, rock cairns and piles may indicate the presence of other Apache sites. Consultations with the Mescalero Apache Tribe did not result in the identification of Traditional Cultural Properties or other sacred sites within the proposed SRS boundaries. Because of these issues, construction and operations would be planned in such a way as to maintain the integrity and the character of there important cultural features at SRS as defined by the State Historic Preservation Officer and the Advisory Council on Historic Preservation.

4.6.2 NO ACTION ALTERNATIVE

Under this alternative, the SRS would not be constructed. If this were to occur, no action would be required to mitigate identified archaeological resources. Although archaeological surveys in the project area may have increased public attention, steps have been taken to minimize the possibility of vandalism. Site descriptions have been provided to the Archaeological Records Management System at the Museum of New Mexico in Santa Fe. Copies of reports and site forms will be on file at the State of New Mexico Land Office and the BLM, Las Cruces District Office. All three repositories maintain confidentiality for archaeological site data. Only the natural processes of wind and water erosion and existing land uses (such as livestock grazing and recreational uses) would continue to affect the prehistoric and historic archaeological sites if no further action is taken with respect to the proposed SRS project.

4.6.3 MINIMAL SRS INFRASTRUCTURE ALTERNATIVE

Under this alternative, the full SRS complement of facilities would not be constructed. As an example, the cryogenic fuel plant would not be built. There would be fewer permanent buildings, and less infrastructure would be needed. About the same amount of land would be disturbed and about the same number of cultural resource sites would be affected as with the proposed action. Visual effects on El Camino Real would not be materially reduced. The major visual impact would be from the cryogenic fuel storage vessels, which would have the same capacity as for the proposed action. The M&I facility, launch/landing complex, and airfield areas would remain the same. The same mitigation measures would be implemented as were discussed in Subsection 4.6.1, beginning on page 237.

4.7 NOISE

This section estimates noise emissions expected to be generated by SRS construction and operations sources. Effects on noise receptors in the SRS area also are estimated. Noise receptor is the term commonly used in NEPA documents to refer to either humans or animals in the context of their response to noise. Human noise receptors would include SRS workers and visitors, ranch workers, railroad workers, recreational users, and the general public. Animal receptors of greatest concern would include migratory and nonmigratory birds and mammals. New noise sources associated with the proposed SRS and the areas they would affect are listed in Table 41.

Table 41. New Sources of Noise That Would Be Associated with the Proposed SRS

Noise Source	Area Impacted
Construction	
Construction equipment	SRS
Vehicles	SRS
Operation	
Rocket engines during launch and landing	SRS and surrounding area
Sonic booms during launch	Downrange areas
Sonic booms during reentry and landing	SRS and along flight path
Cryogenic fuel plant (industrial noise)	SRS
Motor vehicles including on-site light vehicles, privately-owned vehicles, and ground support equipment	SRS
RLV maintenance operations	SRS
Aircraft using the airfield	Primarily SRS, much lower noise levels outside boundaries

As will be discussed in Subsection 4.8.2.1, beginning on page 258, the NMSLO would be responsible for developing the planning documents that would be implemented for the management of SRS natural resources. These plans would be drafted in consultation with the USFWS and New Mexico natural resource management agencies. The planning documents would be coordinated with all of the regional and State agencies and would include provisions for monitoring the effects of noise on wildlife.

Both the American Conference of Governmental Industrial Hygienists (ACGIH) and OSHA publish guidelines for workplace noise exposure. Although the OSHA regulations have the force of law, ACGIH limits tend to be more conservative so ACGIH limits were used in this document. In addition, OSHA frequently adopts ACGIH limits when they are more conservative.

4.7.1 CONSTRUCTION

The primary source of noise during construction of the SRS would be the large, motorized equipment that would be used. Other construction vehicles also would contribute to the noise.

4.7.1.1 Proposed Action

Noise effects of construction of the proposed SRS were analyzed with the same assumptions used for the air quality analysis Subsection 4.4.1.1, beginning on page 213. Representative noise levels associated with construction equipment were taken from D. N. May (1978) and are summarized in Table 42.

At any point along a road under construction, at a building site, or at a gravel or borrow pit, it was assumed that no more than four pieces of equipment would be in operation simultaneously within 50 feet of a noise receptor. Although the entire fleet of road construction equipment could be in operation, it would be spread over a substantial area. Trucks being used to haul materials could be spread along miles of road.

Table 42. Typical Noise Levels of Construction Equipment

Equipment	Noise Level at 50 ft (dBA)
Heavy off-road truck	91
Derrick crane	88
Paver	88
Jackhammer	88
Scraper	88
Loader	88
Winch	88
Bulldozer	87
Backhoe	85
Concrete hauler	85
Compressor	81
Generator	76

Data Source: D. N. May (1978)

To estimate the maximum noise level likely to be encountered, it has been assumed that one bulldozer, one scraper, one loader, and one truck would be in use at nearly the same point. At a building site, other types of equipment would be used, but the noise level would be similar. The composite noise level would be 95 dBA 50 feet from the source. Disregarding atmospheric attenuation, noise levels would be 75 dB at 500 feet and 69 dB at 1,000 feet. At greater distances, there is a likelihood that additional pieces of equipment would be within the specified distance from a receptor. Therefore, two additional trucks were assumed to be 1 mile from a receptor for the purpose of estimating the sound level at that distance. The result is an estimated level of 56 dBA at 1 mile from the major activity. On a calm day, this level would be audible to most people.

The ACGIH recommends a workplace exposure limit to noise of 16 hours at 80 dBA, 8 hours at 85 dBA, and half the preceding exposure time for each successive sound level increase of 5 dBA (ACGIH 1993). The 85-dBA level would be reached at 160 feet and 80 dBA would be reached at 280 feet from the postulated construction activity. This means that beyond 280 feet from construction activity—160 feet for workers present no more than 8 hours per day—there would be no need for hearing protection for workers. Workers closer than 280 or 160 feet may require hearing protection. Workers in the immediate vicinity of construction sites—especially those operating heavy equipment—would definitely require hearing protection. It should be noted that construction activity may be punctuated with occasional, very brief, higher sound levels such as those associated with loading rocks into a truck; however, such transient events are inherently included in the sound level measurement.

Construction is assumed to take place for ten hours at any single point, with no work taking place between 10 p.m. and 7 a.m. If there are noises between these times, they must be increased by 10 dB when the day-night average sound level (DNL) is computed. Using the preceding assumption, DNL associated with this activity would be 91 dBA at 50 feet and 71, 65, and 52 dBA at 500 feet, 1,000 feet, and 1 mile respectively. The HUD criterion (Subsection 3.7.3, beginning on page 139) of 65 dBA for residential development (24 CFR §51.104) would be met at points 1,000 feet or more from major construction activity. Four (4) miles or more from intensive construction activity, the noise level would be no higher than the existing background level.

Intensive road construction activity would occur at any one point for a relatively short period of time. It is likely that only gravel and borrow pits—and some building sites—would have intensive activity for the duration of the construction activity. Because of the isolated nature of the proposed SRS, effects of construction noise on the general public would be minimal. Subsection 4.5.1.5, beginning on page 230, contains a detailed discussion for effects of noise on wildlife.

4.7.1.2 No Action Alternative

Under this alternative, the SRS would not be developed. There would be no construction and no associated noise or noise impacts. Existing noise sources would continue.

4.7.1.3 Minimal SRS Infrastructure Alternative

Under this alternative, many permanent structures would not be built; rather, temporary structures (office trailers) would be used. Also, the cryogenic fuel plant would not be constructed. Road paving would be reduced by approximately 50%. Both the level and duration of noise would be reduced even further from the levels projected for the proposed action.

4.7.2 OPERATIONS

Operations noise sources are listed in Table 41, on page 241. Because many of these sources are well understood, the noise levels can be estimated with reasonable accuracy. Elements associated with launch and landing operations, however, are somewhat dependent on details of the RLV that are yet to be designed. For this reason, conservative assumptions were used in projecting noise levels.

4.7.2.1 Proposed Action

Launch Operations

Rocket engines generate intense sound levels. A model developed by the Chemical Propulsion Information Agency (CPIA 1971) could be used to estimate the noise level produced by rocket exhaust if the thrust, exhaust velocity, and acoustic efficiency of the engines are known. At the present time, engine designs have not been finalized. Fundamental design parameters such as the size, weight, thrust requirements, and aerodynamic shape of the vehicle are not firmly established. Given this situation, it is not possible to predict with a high degree of confidence the noise characteristics of this new class of vehicles. For this reason, noise data available for the Space Shuttle was used for this analysis.

An important noise level limitation for launch operations is 115 dBA. This is the highest level to which workers should be exposed without using hearing protection (ACGIH 1993). At 115 dBA, workers may be safely exposed for 7.5 minutes. Examination of the Space Shuttle can help establish an upper limit on the noise produced by an RLV. Very large aluminized solid rocket boosters, such as those used on the Space Shuttles, produce exceptionally turbulent exhaust flow and very high noise levels. A completely liquid-fueled RLV with comparable thrust would produce a comparable noise level.

The Space Shuttle produces a sound level at liftoff of 175 dBA at 50 feet from the launch pad. This level would be attenuated to a level of 115 dBA after propagation over a distance of 4 miles from the launch site assuming the conservative estimate of 1.5 dB per kilometer for atmospheric absorption. Because the distance from the launch/landing complex to the nearest boundary of the proposed SRS would be greater than 4 miles, the 115 dBA contour would be completely contained within the SRS boundary. Any person—worker or member of the public—within the 115 dBA contour would require hearing protection. Individuals inside buildings would be protected by the structure.

The RLVs launched from the proposed SRS would climb nearly vertically to an altitude of at least 60,000 feet before pitching over to begin accelerating horizontally. Therefore, the line-of-sight distance between the launch vehicle and ground personnel outside the 115 dBA contour would always be sufficient to limit exposure. The Draft Environmental Assessment for the X-33 program (NASA 1996b) estimated that an X-33 launch would produce a 110 dBA level at 3.8 miles, which extrapolates to 115 dBA at approximately 2.5 miles. It is likely that the larger commercial derivative would be noisier than the X-33 but no noisier than the Space Shuttle.

The important conclusion is that the 115 dBA sound level contour at launch would be completely contained within the area set aside for the SRS. The public would be excluded from this area. Workers would be evacuated temporarily, protected by buildings, or provided with hearing protection. Because the time from liftoff to orbital insertion of most launch vehicles is in the range from 7 to 10 minutes, the 7.5-minute, 115 dBA exposure limit would not be reached outside the SRS boundaries. Launch noise also was estimated for various nearby communities and ranches. The duration of the maximum level would be less than 2 minutes. These estimates are given in Table 43 along with the predicted day-night average sound levels on launch days. In some cases, the contribution to the average levels would be below the background noise level. In all cases, they are below 65 dBA.

An RLV landing horizontally would produce a much lower noise level compared with a launch because it would either be unpowered or would have much lower thrust compared with

Table 43. Predicted Launch Noise Levels for Nearby Communities and Ranches

The duration of the noise at the maximum level would be less than 2 minutes.

Location	Predicted Launch Noise Level (dBA)	Predicted DNL on Launch Days (dBA)
Truth or Consequences	67	39
Rincon	63	34
Hatch	59	30
Engle	81	52
L7	91	62
Cutter	93	64

launch. An RLV landing vertically would potentially produce sound levels during landing comparable to those during launch and of comparable duration.

Sonic Booms

A shock wave is produced whenever a vehicle exceeds the speed of sound. When the shock wave reaches a receptor, a sonic boom is heard. The term overpressure is used to describe the effect of any shock wave, be it from a sonic boom or an explosion. When the wave reaches a receptor, the normal pressure exerted by the atmosphere is increased until the wave has passed. The magnitude of the pressure increase from a sonic boom varies from less than one pound per square foot (psf) produced by a small aircraft to as much as 13 psf produced by certain space vehicles. The pound per square foot is a unit of pressure 144-times smaller than the more commonly used pound per square inch.

A sonic boom would be produced during both launch and landing of the vehicles. The shock wave propagates away from the vehicle in a manner completely analogous to the wake of a boat. Although sonic booms are of short duration, potential damage to structures must be considered, as well as effects on receptors. With specific knowledge of the launch vehicle, its trajectory, and atmospheric conditions, it is possible to predict the intensity and ground track of the sonic boom. The nature of the shock wave is such that it propagates outward in the form of a cone at an angle to the line of flight with a velocity component in the forward direction. If the vehicle is traveling vertically, the shock wave propagates upward and does not intersect the ground. Only when the vehicle has a sufficient horizontal velocity component can the sonic boom reach the ground under normal atmospheric conditions. Propagation of sonic boom shock waves is illustrated in Figure 32. The arrows indicate the direction of propagation of the relevant part of the shock wave. The figure also depicts the fact that as the vehicle gains speed, the angle of the cone narrows.

At a receptor location, the magnitude of a sonic boom shock wave produced by a supersonic vehicle is influenced by a number of factors

- The speed of the vehicle (beyond Mach 1.3, the strength of the shock wave increases very little)
- The altitude of the vehicle
- The trajectory of the vehicle
- The shape, size, and weight of the vehicle
- Atmospheric conditions

Vehicles such as the Space Shuttle and the Titan IV have complex shapes. Because the exhaust gas plume is very large, shock wave energy results from the supersonic motion of the plume through the surrounding air in addition to that from the hard body of the vehicle. During launch, individual shock waves are produced by the nose, the strap-on boosters, the exhaust plume—and, in the case of the Shuttle—by the fuel tank, wings, and tail. These individual waves coalesce to form the overall shock wave structure which at a receptor location may be experienced as more than one “boom.” Research has shown that vehicles as different as the Space Shuttle, Titan IV, and Saturn 5-Apollo produce similar shock waves (Holloway, et al. 1975; Stewart 1993). Measurements and predictions of conventional space launches indicate an

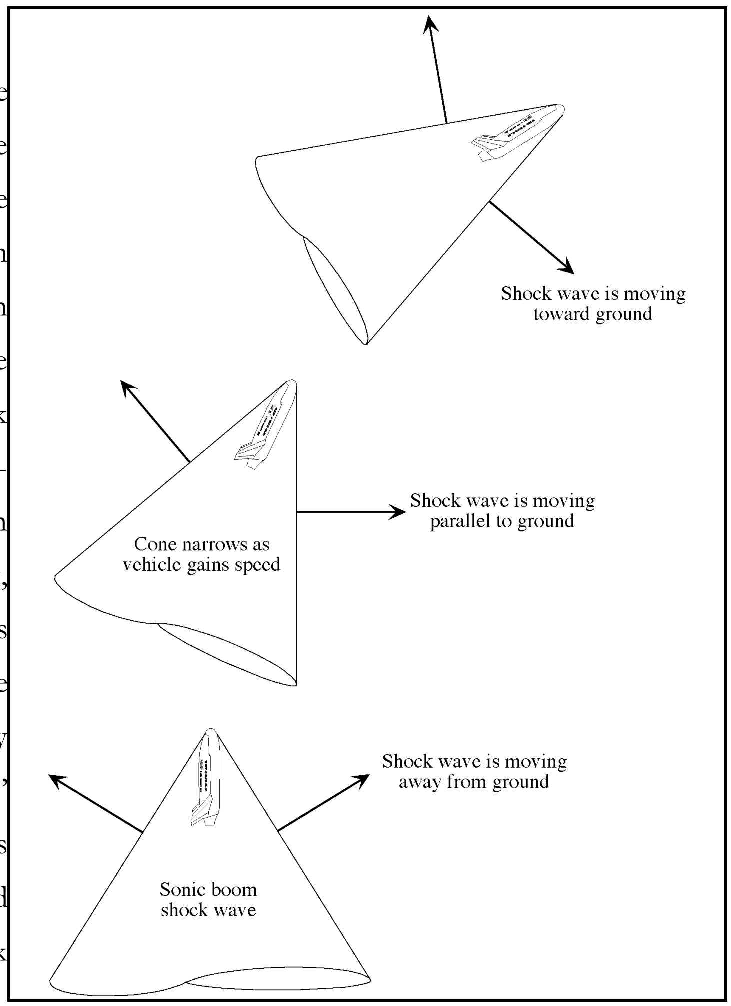

Figure 32. Shock Wave Propagation During Launch of a Space Vehicle. The arrows represent the direction of propagation of the relevant part of the shock wave at three points during ascent.

overpressure as great as 13 psf may occur in a very narrow "focal region" of the sonic boom footprint, and 1 psf in a far wider region (Stewart 1993). Research indicates that an overpressure of 10 to 11 psf will not cause structural damage in buildings, but may cause damage to plaster, windows, and other nonstructural components (ICAO 1970; NASA 1995). At 1 psf, there is very low risk of damage. Humans can be exposed to 20 psf without injury (NASA 1995).

On most space launches, including the Space Shuttle, the shock wave first reaches the ground at a point about 35 miles from the launch site (Holloway et al. 1975). The duration of the shock wave from a space vehicle during launch typically is longer than that from aircraft, up to a few seconds compared with 0.1 to 0.5 seconds (Carlson 1978; USAF 1996).

An RLV, with its simpler shape, would produce a somewhat less intense shock all other factors being equal. The RLV launch profile, however, would result in significant reduction of the magnitude of the sonic boom shock wave at ground level. Existing orbital launch vehicles pitch-over shortly after lift-off to begin gaining horizontal speed for orbital insertion, and typically the shock wave begins to reach the ground at a downrange distance of 35 miles. Curvature of the path and acceleration of the vehicle lead to a focusing effect that increases the maximum intensity of the wave in a very narrow band along the vehicle ground-track. RLVs to be launched from the SRS would not begin to gain significant horizontal velocity until they had achieved an altitude of 60,000 to 100,000 feet. This would greatly reduce the maximum overpressure at the ground. Although at 60,000 feet, the ground footprint of the sonic boom would be about 60 miles wide the expected overpressure would be less than one-fourth of the magnitude that would result from a conventional trajectory (NASA 1995). The area subjected to overpressure as high as 3 psf would be very small, and no communities would be within the area, only isolated individuals. In any case, 3 psf is insufficient to cause hearing damage. The main effect would be minor annoyances in the form of a startle effect. If pitchover occurred at 100,000 ft, the maximum magnitude would be even smaller, approximately 1 psf. Thus the highest overpressure expected for SRS launches would be approximately 3 psf. The highest expected overpressure is within the 2- to 5-psf overpressure range in which rare, minor, nonstructural building damaged is expected (USAF 1996). The area potentially affected by sonic boom overpressure as high as 3 psf would be a very thin crescent approximately 1 mile wide at the center and tapering to zero width at the edges. It would extend approximately 25 miles on either side of the flight path and would contain approximately 25 square miles. The precise area would vary with the trajectory and with atmospheric conditions. The area would vary somewhat from launch to launch even on the same azimuth. For most launch azimuths, the area with 3-psf overpressure would be contained within WSMR, and no residences would be affected. For a 140-degree azimuth launch, about 10% of the area subjected to overpressure greater than 3 psf would fall outside WSMR. Using average population density data, approximately 6 residents would be expected in this area. For a 22-degree azimuth launch, about 50% of the 3-psf area would fall outside WSMR in a very sparsely populated area. Approximately 5 residents would experience 3-psf overpressure. For a 357-degree launch azimuth, nearly all of the 3-psf area would fall outside the missile range. The crescent would cross the Rio Grande Valley but would not intersect any communities. Population in the valley portion is sparse and in the remainder, very sparse. Approximately 20 residents would experience 3-psf overpressure. There would be no risk of damage to Elephant Butte or Caballo Dams. These are massive concrete structures that have been designed to withstand the much larger forces generated by moving earth and water. The decibel equivalent of 3 psf is 137 dB which is below the occupational exposure limit of 140 dB for impulsive sounds, and 1 psf is equivalent to 128 dB. An overpressure of 10 psf is comparable to that experienced during a typical fireworks display or to thunder from a close lightning strike. The primary effect of most sonic boom noise on humans is a startle effect. There are no known traditional cultural or religious activities that take place within the area potentially affected by sonic booms.

On reentry, the Space Shuttle produces a maximum sonic boom overpressure of no larger than 1.5 psf. The overpressure exceeds 1 psf over only a small area. It can be assumed that an RLV would follow a reentry trajectory similar to that of the Shuttle, but it would be comparable in size to the launch configuration of the Shuttle, i.e. with attached external fuel tank and solid rocket boosters. It would be much larger than a Space Shuttle Orbiter. Therefore, the magnitude of its shock wave could be somewhat larger than that of a Shuttle, but it is not likely that it would exceed the estimated maximum launch level of 3 psf. The major difference between the launch and landing sonic booms is that the launch boom would be heard along the flight path beginning a considerable distance, 35 miles or more, downrange from the SRS. At increasing downrange distances, the magnitude of the sonic boom would continually decrease. The landing sonic boom would be heard along the landing track and would be reach its highest levels much closer to the SRS. Up to 10% of the public in affected areas can be expected to report annoyance when exposed to sonic booms at 1 to 1.5 psf (Holloway et al 1975), but because of the sparse population near the SRS, the number of people potentially affected would be small.

Summary of Launch and Sonic Boom Noise

The important conclusions with regard to launch noise and sonic boom noise are

- Launch noise would necessitate hearing protection only within the boundaries of the SRS.
- Sonic booms during launch or landing would subject the public to overpressures no greater that 3 psf, which would not result in injury, hearing damage, or structural damage to buildings; however, nonstructural damage to buildings might occur on rare occasions.
- Only a small number of people are likely to report annoyance with sonic boom noise.
- As discussed in Subsection 4.5.1.5, beginning on page 230, serious adverse effects to wildlife, including desert bighorn sheep in the San Andres National Wildlife Refuge, would not result from launch noise and sonic booms.

Detailed noise analyses, including launch and landing sonic boom analyses, would be performed on all vehicles to be launched from the SRS.

Operation of the Cryogenic Fuel Plant

The cryogenic fuel plant would be operated with a combination of electrically-driven compressors and a combustion-driven boiler. According to Johansen et al. (1992), the plant could be expected to produce a noise level within its perimeter of 114 dBA. The noise level produced by the hydrogen portion of the plant would be 42 dBA at 2,600 feet. The combined hydrogen/oxygen plant would produce a level of 45 dBA at 2,600 feet. This level would be audible and would exceed the background noise level under low wind conditions, but it would be below the wind-dominated background level under moderate-to-high wind conditions. Most of the noise would emanate from compressors. SRS personnel working in or near the cryogenic fuel plant would be required to wear hearing protection.

The 85-dBA level would be reached approximately 150 feet from the facility. At a half-mile, the level would be reduced to approximately 45 dBA, which is well below the level that would disrupt conversation although well above the background noise level. Therefore, the noise effects on SRS visitors and workers in other areas would be minimal. The general public would not be affected. The area in which noise levels from the cryogenic fuel plant would exceed 85 dBA would occupy 0.01% of the total SRS area.

Vehicle, Rail, and Air Transportation

Planning in the Noise Environment (DA 1978) provides a method to estimate vehicle noise using a nomograph. In a hypothetical situation in which 500 light, 10 medium, and 10 heavy vehicles per day would pass along a single section of paved road at 45 mph, the predicted equivalent noise level would be approximately 58 dBA at points 50 feet from the road. Similar results were obtained along roads used by employees commuting to the site and for duty-related travel. Thus, vehicular traffic noise would be minimal. Likewise, the infrequent use of the short rail spur would produce inconsequential noise.

Of the transportation sources, only the airfield would have the potential to produce significant noise. This document uses the FAA methodology to analyze the noise effects of the airfield. Airfield noise assessments usually rely on the day-night average noise level DNL. Noise contours can be calculated with a computerized noise model, but it was not necessary to do so in this case because of the low traffic volume. Instead, the DNL value was computed manually. It can be compared with other noise levels in this analysis.

A variety of aircraft types might use the airfield at the proposed SRS. Possible types include

- Aircraft similar to the NASA Shuttle transporter designed to carry large vehicles or components externally in piggyback fashion
- Aircraft similar to the Orbital Sciences Pegasus launch platform aircraft that carry vehicles externally under the aircraft
- Standard cargo aircraft such as freighter versions of the Boeing 747 and the USAF C-5
- "Super Guppy" type aircraft, i.e. those with a highly modified oversized fuselage and designed to carry large objects internally

Because the types of aircraft that would use the airfield is speculative at this time, the noise analysis was based on the USAF C-5, the largest aircraft operated in the United States. C-5 take-off and approach speeds and measured noise levels were used. The data were taken from Speakman et al. (1978).

Because of the low volume of operations and because it is unlikely that more than one operation would be conducted on a single day, manual calculational methods were used. It was assumed that all aircraft operations would occur during daylight hours. For take-off, a 10-degree climb angle was assumed, and for approach, a 3-degree glide path was assumed. These are conservative assumptions because they would keep the aircraft near the ground along a very long flight path. For the C-5, the take-off noise level is 114.5 dBA at 500 feet, and the approach noise level is 112.2 dBA at 500 feet. Speakman et al. (1978) provide a tabular listing of the noise level for several flight configurations at various distances. Using the data, the exposure time was computed for take-off and approach. Taxiing was assumed to require 10 minutes at "taxi power." For ground operations, the 65 DNL contour would extend no more than 2,500 feet from the aircraft if it were stationary. Because the aircraft would be in motion during most of its ground time, 2,500 feet is a conservative estimate of the extent of the 65 dBA contour. For take-off operations, the 65 DNL contour at its widest would be approximately 3,200 feet wide centered on the flight path. By mathematically summing the incremental noise level along the path, the 65 DNL contour can be shown to extend 9,070 feet beyond the lift-off point. For approach, the same methodology shows that the 65 DNL contour would be 4,000 feet wide at its widest point and would extend back along the flight path 7.2 miles from the touch-down point. For both take-off and landing, the contour would taper to a point at the extreme distances from the airfield. The take-off contour would be entirely within the SRS for take-off either to the north or south. For approach from the south, it would be entirely within the SRS, but for approach from the north, it would extend approximately 4 miles beyond the boundary into an unpopulated area. Except in the immediate airfield area, the maximum length of time over which the sound level would exceed 65 dBA would be approximately 1 minute for both take-off and landing. Therefore, the effects of airfield noise on the public would be minimal. Potential effects of airfield noise on wildlife and domestic animals are considered in Subsection 4.5.1.5, beginning on page 230.

Maintenance and Integration Operations

M&I procedures—such as use of power tools—could result in highly localized noise. Much of this type of activity would take place within the M&I facility. Although it is possible that workers would require hearing protection part of the time, it is unlikely that noise levels beyond the immediate vicinity of the activity would be significant. The need for hearing conservation measures would be addressed by the SRS ES&H program.

Cumulative Noise Effects under the Proposed Action

Of the major operational noise sources at the proposed SRS, only the cryogenic fuel plant would be a steady source. Noise resulting from vehicular traffic on the road network would occur throughout the day, but would be somewhat variable in intensity. Noise resulting from aircraft operating from the airfield and from RLV operations would occur for occasional brief periods. Launch or recovery of an RLV would not occur at the same time as aircraft operation, nor would ground vehicles be in motion within the safety zone during a launch.

Neither the fuel plant nor the road network would be a significant noise contributor in most of the SRS or in any area outside its boundaries. For example, at the airfield—about 1.5 miles from the fuel plant—the attenuated noise level would be approximately 35 dBA. This level would be below the background level. Aircraft operations would contribute to the noise level in a much larger part of the SRS, and RLV launches would contribute throughout the SRS. At the rate of RLV launches and aircraft operations projected for the SRS, a location near the cryogenic fuel plant would be exposed to launch noise for approximately 2 minutes at an intensity level of about 145 dBA, to two aircraft noise events for approximately 1 to 2 minutes each with a peak intensity level of at most 114 dBA (this assumes two low overflights), to continuous plant noise at a level of 85 dBA, and to traffic noise at an average level of 58 dBA. In most of the SRS, and in all areas outside the SRS, only launch and sonic boom noise would be audible. Cumulative noise exposure would not significantly increase the impacts of noise to SRS workers, to the public, or to wildlife.

4.7.2.2 No Action Alternative

Under this alternative, the SRS would not be constructed or operated. There would be no noise generated.

4.7.2.3 Minimal SRS Infrastructure Alternative

Under this alternative, noise that would result from the construction of deleted components of the proposed action would not occur. Because the cryogenic fuel plant would not be constructed, the noise resulting from its operation would not occur. Noise associated with launch and recovery of space vehicles would be the same as under the proposed action. Most of the SRS road network would remain unpaved. Vehicular traffic on unpaved roads would produce noise levels a few dB higher than on paved roads, but vehicular noise would still be insignificant.

Electrical Generator Noise

Under this alternative, electrical power would be supplied by generators. Under the proposed action, the peak electrical power requirement (without the cryogenic fuel plant) is estimated to be a high of 5 MW. Most of the time, the power requirement would be considerably smaller. A facility of reduced size and scope would require a peak power level comparable with the proposed action. During nonpeak times, the power requirement would be much smaller and overall electrical energy requirements would be reduced. The assumptions for generator use under air quality in Subsection 4.4.2.3, beginning on page 225, were used.

As shown in Table 42 on page 243, a typical generator produces a noise level of 76 dBA at 50 feet. Although it would be impractical to provide 5 MW of power with collocated generators as small as 100 kW each, assuming the use of 50 generators of this size would be a very conservative noise estimate. Fifty 100-kW generators in close proximity would produce a cumulative sound level of 93 dBA. At 200 feet, the level would drop to 81 dBA. While hearing protection would be required in the immediate vicinity of the generators, noise levels beyond 200 feet would be minor to moderate. Approximately one acre would be subjected to noise at or above 81 dBA. In reality, either a small number of large generators would be used, or small generators would be positioned at different locations within the SRS. In either case, the noise impacts would be smaller than those analyzed here.

Cumulative Noise Effects under the Minimal SRS Infrastructure Alternative

Under this alternative, the cryogenic fuel plant would not be constructed. In most of the SRS, and in all areas outside the SRS, only launch noise would be significant. It is unlikely that cumulative noise exposure would significantly increase the impacts of noise to SRS workers, to the public, or to wildlife.

4.8 LAND OWNERSHIP AND USE

Establishment of the SRS would require New Mexico to acquire Federal and private land within the proposed SRS boundaries. The change in management practices initially would have minor impact on land use outside of SRS-related activities. Most of this land, including some currently managed by the NMSLO, is within the Western WSMR Call-Up Area. Acquisition of Federal and private land within the SRS boundaries would not affect the existing relationship between the NMSLO and WSMR. WSMR land-use requirements would be considered in the land acquisition process.

4.8.1 LAND OWNERSHIP

4.8.1.1 Proposed Action

Ownership of approximately 195,976 acres of land needed for the proposed SRS would change. Approximately 6,767 acres of private land in Sierra and Doña Ana counties would be acquired by the State of New Mexico. Another 189,209 acres of BLM land would be exchanged for State Trust Land located elsewhere. With all of SRS land under State control, BLM management practices and existing BLM RMPs no longer would apply. Current private landowners in the affected area would have the options of either relocating or remaining on the land for remainder of their lives (i.e., retaining a "life estate"). Taxes on private land acquired by the State no longer would be available to Sierra or Doña Ana counties to fund schools, law enforcement, and other community services as discussed in Subsection 4.10.4, beginning on page 288.

4.8.1.2 No Action Alternative

If the proposed SRS is not developed, there would be no affect on the current land ownership status. BLM land management policies and practices would continue on Federal land and NMSLO practices would continue for State Trust Land. There would be no displacement of private land owners and no change in the local tax structure.

4.8.1.3 Minimal SRS Infrastructure Alternative

The amount of BLM and private land needed to be acquired for construction and operation of the proposed SRS would remain the same as under the proposed action. The use of temporary structures and other infrastructure reductions would have no net affect on land ownership requirements.

4.8.2 LAND USE

Neither Sierra nor Doña Ana County has a comprehensive land-use plan in place. However, Sierra County has an *Interim Land Use Policy Plan* that was published in 1991. Among the policy provisions are the following:

- ". . . it is the policy of Sierra County that federal and state agencies shall inform local governments of all pending actions affecting local communities and citizens and coordinate with them in the planning and implementation of those actions."

- “. . . all federal and state agencies shall comply with the Sierra County Land Use Policy Plan and coordinate with the County Commission for the purpose of planning and managing federal and state lands within the geographic boundaries of Sierra County, New Mexico.”
- “The general public, the state of New Mexico and local communities shall be notified of, consulted about, and otherwise involved in all federal and state land adjustments in Sierra County.”

Even though Sierra County may not have legal authority to impose restrictions on disposition or management of Federal or State land, the County Commission and the public would be afforded the opportunity to participate in decisions concerning Federal-State land exchanges required to consolidate State land holdings for the SRS. In general, the intent of the Sierra County land-use policies would be adhered to as much as possible except where legal conflicts presented a problem. Thus, some conflicts between the proposed action and Sierra County policies possibly could arise. There are no other county or municipal land-use plans, policies, or controls in effect in the SRS project area.

If BLM land is exchanged for State land as proposed, the Caballo and Mimbres RMPs, together with their objectives, would not be implemented. Instead, the SRS land would be subject to NMSLO and SRS management objectives. There would be no conflict with the BLM plans once an exchange was completed because they would no longer apply to the SRS area. There are no foreseeable conflicts between the proposed action and the objectives of Federal, State, local, and Native American tribal land-use plans, policies, and controls.

4.8.2.1 Land-Use Management Plans

After land acquisition from the BLM and private landowners, the NMSLO would lease the land to the appropriate State agency for use as a spaceport. It is anticipated the NMOSC, or a successor State agency, would be the designated lessee. The spaceport lease fee would be determined by the land's market value, intensity of use, phasing of the development, and potential environmental risks. The NMOSC would then sublease to private sector tenants and charge user fees. The revenues generated from this lease would be distributed to New Mexico's educational institutions in accordance with the laws and regulations governing the State Trust Land and its beneficiaries.

As the steward of the State Trust Land, the NMSLO has the ultimate responsibility for the overall land management. This would include the responsibility for the development and implementation of the management plans that would flow down to the NMOSC as lease stipulations. These management plans would be site-specific for the proposed SRS but would be equivalent and compatible with the current resource management practices exercised for other State Trust Land managed by the NMSLO. The State management plans would include operational management processes as well as natural and cultural resources management.

The cultural resources management would be coordinated with the State Historic Preservation Officer, New Mexico Historic Preservation Division, Office of Indian Affairs, and the Bureau of Land Management. The plan would reflect the NHPA Section 106 consultations, and implement the provisions of the Programmatic Memorandum of Agreement between the NMSLO, State Historic Preservation Officer, BLM and the Advisory Council on Historic Preservation. Additionally, input would be made for enhancement and protection of El Camino Real in cooperation with the National Park Service.

The natural resources management would address protection and enhancement of the SRS ecological environment, protection and recovery of any endangered and threatened species and habitat, and the continuation of the current multi-purpose land-use system. Included would be guidance and direction on such subjects as

- Construction management practices to include obtaining and adhering to applicable permits; protection of cultural resources; protection of Federal and State endangered, threatened, proposed species, and inclusive habitat; minimization of impacts to raptor and neotropical migratory bird species, and other Federal and State sensitive species.
- Long term protection of potential Federal and State endangered, threatened, proposed species, and inclusive habitat. Establishment of monitoring and recovery programs in cooperation with Federal and State agencies.
- Establishment of programs for revegetation and biodiversity recovery, including potential ecological monitoring of the exclusive-use area for birds protected by the Migratory Bird Treaty Act (MBTA).
- Adherence to the Programmatic Memorandum of Agreement for cultural resources management.

- Acquisition and adherence to appropriate air and water quality and hazardous/toxic materials and waste management permits.

The NMSLO resources management plans would be coordinated with the applicable Federal and State resource and regulatory agencies. This also would include the appropriate level of consultation required under Federal law. The natural resources management plans and requirements would be drafted and approved in cooperation with the U.S. Fish and Wildlife Service according to Section 10 consultation requirements of the Endangered Species Act. NMSLO also would cooperate and consult with the NM Department of Game and Fish and the NM Department of Energy, Mineral, and Natural Resources in the formulation of potential ecological protection and monitoring programs.

4.8.2.2 Projected Land-Use Impacts

Establishment of the SRS would constitute a major change in the current land use of the area. Aside from changing the present and future major land use of the site from livestock production to high technology commercial uses, the principal impact on present land-use practices would involve the setting aside of specific areas for exclusive SRS functions.

Proposed Action

To adequately assure reasonable safety to the general public using land within the proposed SRS boundaries, approximately 27 sections (17,280 acres) of the 386-section SRS area would be reserved for the exclusive use of SRS-related activities. The approximate boundaries of this area are shown in Figure 33. This area comprises approximately 7% of the SRS. Outside of this initially excluded area, the present multiple land uses would be continued under the specifications and management practices of the NMSLO. Incremental differences in the various land-use practices (e.g., limitations on ORV use) would reflect the differences between BLM and NMSLO management practices.

Figure 33. Exclusive Land Use Areas

It is assumed that the proposed action would transfer Federally-managed public land and minerals out of Federal ownership, and thus remove the potential for Federal mineral claims related to mineral rights within the proposed boundary of the site. However, the opportunity to mine within the boundary would remain through State leasing of mineral rights. Only those areas reserved for the exclusive use of SRS-related activities would be withdrawn from mineral location and mining.

No Action Alternative

If no action is taken to construct the proposed SRS site, there would be no effect upon land use or status at the site.

Minimal SRS Infrastructure Alternative

The reduced type and scope of the infrastructure would have the same net effect as the proposed action. Temporary buildings and trailer-based facilities would replace permanent construction. The footprint of the area disturbed by construction activities would not be significantly different than the area disturbed under the proposed action. Therefore, there would be no changes in the land-acquisition requirements. Possible conflicts with Federal, State, local, and Indian tribal land-use plans, policies, and controls would be the same as for the proposed action.

4.9 VISUAL, ESTHETIC, AND RECREATIONAL RESOURCES

This section analyzes the potential impacts for visual, aesthetic, and recreational resources related to the proposed SRS project.

4.9.1 VISUAL RESOURCES

The visual resource impact assessment is based on visual contrast, visibility variables, and the degree to which the visual contrast is within acceptable limits of the VRM classes. Contrast ratings provide a criterion to analyze potential visual impacts of man-made objects and landscape alterations associated with proposed projects. Contrast ratings are done from key observation points (KOPs) that are selected on the basis of their accessibility and their line-of-site to man-made objects and landscape alterations. For the proposed SRS, contrast ratings were done from seven KOPs along commonly traveled routes, El Camino Real, and at three residences. Degrees of contrast (none, weak, moderate, or strong) were evaluated and assigned for each KOP. The KOPs used in the analysis are shown in Figure 26, on page 154, and their ratings are

KOP		Degree of Contrast
1.	Residence at the base of Prisor Hill	Strong
2.	Residence at Cutter Ranch	Moderate
3.	Residence at Aleman Ranch	Moderate
4.	El Camino Real west of Upham	Strong
5.	El Camino Real on north side of ridge south of Yost Draw	Moderate
6.	Main access road traveling north	Moderate
7.	Main access road traveling south	Moderate

4.9.1.1 Visual Impacts of the Proposed Action

The proposed SCCF, launch/landing complex, FOCC, M&I facility, cryogenic fuel plant and storage facility, and the airfield would appear as development clusters, some with contrasting vertical elements. These facilities are described in Table 44. Vertical elements and surface disturbances where contrasting soil layers were exposed would be the most visible. Distance is a positive factor in reducing the visual impacts for this project because many of the facilities would appear from the KOPs as background views against the San Andres Mountains. All of the proposed SRS facilities are located within the Class III area except three components that are located in the Class IV area—the airfield, the hangar facility, and the water storage tank. In a Class III area, a proposed facility would be evident but subordinate to the existing landscape; whereas, in a Class IV area, a facility is likely to attract attention. A discussion of the classes is in an unnumbered subsection beginning on page 152.

Vertical elements associated with this project could be a significant visual intrusion. Surface disturbance also may be a significant visual intrusion; however, some of these areas would be screened by vegetation or topographic relief. Table 45 summarizes the facility descriptions, including vertical elements, and the potential visual impacts as viewed from each of the seven KOPs.

Table 44. Proposed SRS Facility Description

Area	Proposed Facility	Facility Description	Vertical Elements
RLV Operations Area	3 launch/landing pads	Three 300′ × 300′ concrete bases over 40′ × 60′ trenches; track-mounted rolling shelters with 120′ cranes. Retractable lightning protection system. Approx. 6 acres paved for parking. Security lighting and portable lighting.	120 feet; temporary rods for lightning protection.
	FOCC building(s)	40′× 100′ one-story building, 60′ high pitched metal roof, stucco panels; security lighting. 6,000 sq. ft. of paved parking. 1,200-sq. ft one-story building for communications and power.	60 feet 30 feet
	Radio antenna	Near the FOCC building; discs 12–15 feet above ground.	60 feet
	Cryogenics production facility	20 acres total; 70 feet high with pipes 10 feet above ground with gravel base; paved parking.	70 feet
	Cryogenics storage facility	Two storage areas with similar description as follows: Tanks on 3–5 acres. Tanks would be painted metal. Most would be cylindrical; Some would be spherical storage tanks. The largest tank would be approximately 60 feet high. The entire acreage would be gravel base. All elevated on supports 15 feet above ground. Piping from storage area to launch/landing pads; security lighting.	75 feet
	M&I facility	100′× 120′ building 160′ high, stucco panels, paved parking for 10 cars; security lighting and portable lighting. Payload processing building would be 60′× 80′ one-story; the propellant building would be 45′× 30′ also one-story.	160 feet
	Airfield	Paved, 12,000-ft. runway length and 300 feet wide would utilize 151 acres. Taxiways, docking and undocking area would utilize 131 acres.	
	Hangar facility	120′× 200′ hangar-type metal building 120 feet high. Paved parking for 10 cars; security lighting and possible red lights atop the building.	120 feet
SCCF	Administration building	Two-story building with pitched metal roof, stucco panels, with territorial-style architectural design. Paved parking lot for approximately 100–110 cars. Total surface disturbance estimated at 75 acres. Security lighting.	50 feet
	Radio antenna	Near the SCCF administration building; discs 12–15 feet above ground.	60 feet
	Helipad	50′× 50′ pad, may include a 20-ft. high tower for windsock; 2,500 sq. ft. of paved parking security lighting.	20 feet
	Warehouse Machine shop Equipment building	60′× 60′ pitched metal roof, stucco panels; two-story; 7,500 sq. ft. paved parking lot; security lighting; Three areas combined under one roof. 20′× 50′. 60′× 60′.	50 feet
	Solid waste station	Outdoor transfer location; space for trucks to pull up and collect waste.	
	Fire station/site security office	40′× 60′ prefabricated one-story building with pitched metal roof; surface disturbance includes 3,000 sq. ft. paved parking lot; security lighting.	30 feet
	Railroad terminus and spur	Loading dock with siding for handling materials. Spur would be approximately 5,000 feet in length. Security lighting.	10 feet
SCCF (Continued)	Pyrotechnics storage facility	15′× 20′ one-story structure that would be partially underground..	

Table 44. (Continued)

Area	Proposed Facility	Facility Description	Vertical Elements
Roads and Utilities	Primary access road to the SCCF	From Interstate 25 to Upham, paved upgrade 24′ feet wide, 2-lane road; 45′-wide pavement and shoulders.	
	Secondary access road from primary road to SCCF, cryogenics facility, and the RLV Operations Area	Paved, 2-lane new road; 30′-wide pavement and shoulders.	
	Ferry road	New unpaved road, 100 feet wide, 3.7 miles long; surface disturbance estimate is 55 acres.	
	Electrical distribution lines	40-kV wood-pole structures; overhead from the SCCF substation to FOCC; overhead from the airfield to the launch/landing pads; underground from the FOCC to the launch/landing pads. Surface disturbance would occur at pole sites for overhead; underground would be 10–15′ wide clearing for approximately 1–2 miles (9 acres disturbance). Gravel at substation.	60 feet substation—15–25 feet
	Water storage tank	500,000-gallon steel storage tank; partially screened behind topography atop Prisor Hill; surface disturbance includes road cut and grading at pad site.	20 feet
	Water pipeline	From L7 Ranch to cryogenics production and storage area; underground facility with 10–15′ width within existing road right-of-way except at Aleman Ranch.	

Table 45. Contrast Ratings from the Seven Key Observation Points of the SRS

From KOP	Facilities Not Visible	Facilities Visible	Fg/Mg or Bg	Impact Level
1	SCCF complex, electrical distribution lines, water storage tank, primary access road, secondary access road, water pipeline.	Cryogenic fuel plant & storage facility	fg/mg	High
		Launch/landing complex	fg/mg	High
		FOCC & radio antenna	fg/mg	High
		M&I facility	fg/mg	High
		Airfield	bg	High
		Hangar facility	bg	Moderate
		Ferry road	fg/mg	High
2	SCCF complex, water pipeline, airfield, primary access road, secondary access road, electrical distribution lines, ferry road, water storage tank, FOCC & radio antenna.	Cryogenic fuel plant & storage facility	bg	Moderate
		Launch/landing complex	bg	Moderate
		M&I facility	bg	Moderate
		Hangar facility	bg	Moderate
3	SCCF complex, FOCC & radio antenna, airfield, secondary access road, ferry road, water storage tank.	Launch/landing complex	bg	Moderate
		Cryogenic fuel plant & storage facility	bg	Moderate
		M&I facility	bg	Moderate
		Hangar facility	bg	Moderate
		Primary access road	fg/mg	Low
		Water pipeline	fg/mg	Low
		Electrical distribution lines	fg/mg	Moderate
4	Airfield, railroad dock, primary access road, secondary access road, ferry road, water pipeline, and solid waste station	Cryogenic fuel plant & storage facility	bg	Low
		M&I facility	bg	Moderate
		Launch/landing complex	bg	Low
		FOCC & radio antenna	bg	Low
		Hangar facility	bg	Low
		Water storage tank	bg	Low
		Administration bldg. & radio antenna	fg/mg	High
		Helipad	fg/mg	Low
		Warehouse/machine shop/equip. bldg.	fg/mg	High
		Fire station/site security office	fg/mg	Moderate
		Electrical distribution lines	fg/mg	Moderate
		Pyrotechnics storage facility	fg/mg	Moderate

fg – foreground, mg – middle ground, bg – background

Table 45 (Continued)

From KOP	Facilities Not Visible	Facilities Visible	Fg/Mg or Bg	Impact Level
5	SCCF complex, primary access road	Launch/landing complex	bg	Moderate
		FOCC & radio antenna	bg	Moderate
		Cryogenic fuel plant & storage facility	bg	High
		M&I facility	bg	High
		Airfield	bg	Moderate
		Hangar facility	bg	Moderate
		Secondary access road	fg/mg	Low
		Ferry road	bg	Low
		Electrical distribution lines	fg/mg	Low
		Water storage tank	bg	Low
		Water pipeline	bg	Low
6	Airfield, water pipeline, cryogenic fuel plant & storage facility, launch/landing complex, M&I facility, solid waste station, pyrotechnics storage facility, railroad dock and spur.	Primary access road	bg	Low
		Secondary access road	bg	Low
		Ferry road	bg	Low
		Electrical distribution lines	fg	High
		Water storage tank	bg	Low
		FOCC & radio antenna	bg	Low
		Hangar facility	bg	Low
		Administration bldg. & radio antenna	bg	Moderate
		Helipad	bg	Low
		Warehouse/machine shop/equip. bldg.	bg	Low
		Fire station/site security office	bg	Low
7	SCCF complex	Primary access road	fg/mg	Low
		Secondary access road	bg	Low
		Ferry road	bg	Low
		Electrical distribution lines	bg	Low
		Water storage tank	bg	Low
		Water pipeline	bg	Low
		Launch/landing complex	bg	Low
		FOCC & radio antenna	bg	Low
		Cryogenics fuel plant & storage facility	bg	High
		M&I facility	bg	High
		Airfield	bg	Moderate
		Hangar facility	bg	Moderate

fg – foreground, mg – middle ground, bg – background

Night Lighting

Visual impacts from night lighting would be low during routine operations of the proposed SRS. The proposed lighting design calls for security lighting at most facilities that would include full cut-off lighting for low glare and spill light. Downward light fixtures with low-pressure sodium vapor lamps also would be used. Normally there would be only day shifts at the proposed SRS, and launches normally would occur only during the daytime. Night shifts could be required before some launches for vehicle preparation and could require intense outdoor lighting. It is estimated that on six nights per month visibility could be adversely affected because of outdoor lighting. This would impact both residents and the astronomy enthusiasts using nearby viewing areas.

Fugitive Dust

Fugitive dust would be a visual impact at the proposed SRS area, particularly during construction. Paving of the main access road and the secondary access road would considerably lessen the amount of dust in the air. Aggressive dust control measures would be used during construction to control fugitive dust.

4.9.1.2 Measures to Reduce Visual Impacts

The measures used to reduce visual impacts are in Table 46. Careful siting of facilities, coupled with implementation of these measures, would reduce the potential visual impacts for many of the viewpoints. The majority of the measures for the individual facilities would consist of specifying appropriate colors (whether it be material selection or paint) that would blend with the soil and vegetation of the surrounding area. Color recommendations should be selected from the Munsell Soil Color Charts which are keyed to specific soil types and their respective colors.

4.9.1.3 No Action Alternative

Under this alternative, the SRS would not be constructed and the visual resource issues raised by the proposed action would not apply.

Table 46. Recommended Measures to Reduce Visual Impacts

Facility	Recommended Mitigation Measure
Launch/landing complex	3, 4, 5, 6, 7, 8, 9, 10
FOCC and radio antenna	1, 2, 5, 7, 8, 9
Cryogenic fuel plant & storage facility	3, 4, 5, 6, 7, 8, 9, 10
Airfield	4, 6, 7, 13
Hangar facility	1, 2, 3, 5, 7, 8, 9, 10
SCCF administration building & radio antenna	1, 2, 3, 5, 7, 8, 9
SCCF helipad	3, 4, 6, 7
SCCF warehouse/machine shop/equipment building	1, 2, 3, 5, 7, 8, 9
SCCF fire station/site security office	1, 2, 3, 5, 7, 8, 9
Pyrotechnics storage facility	1, 2, 3, 4, 5, 6, 7, 8, 9
Solid waste station	3, 4, 6, 7, 9
Railroad terminus and spur	3, 4, 6, 7, 9
Primary access road	2, 4, 6, 7, 12, 13
Secondary access road	2, 4, 6, 7, 12, 13
Ferry road	2, 4, 6, 7, 11, 12, 13
Electrical distribution lines	6, 7, 8, 11
Water storage tank	3, 5, 6, 7, 8, 13
Water pipeline	6, 7, 11, 13

Design/Siting	1.	Use consistency in architectural style and design features.
	2.	Use consistency in signage.
	3.	Take advantage of topographic screening when available to lessen visibility from key viewpoints.
Soil/Color Contrasts	4.	Use gravel that is a mix or tan and gray colors.
	5.	Use compatible colors to blend with the existing setting; attempt to match the soil (Munsell Color Charts) and vegetation.
	6.	Minimize exposure of subsoil layers that contrast with topsoil colors, especially white caliche layer near airfield.
	7.	Revegetate or landscape with native vegetation, where appropriate, for covering exposed soils and for dust control.
Reflectivity	8.	Use dull, non-reflective surface treatment or paint structures a compatible color as indicated in #5 above.
Lighting	9.	Use full cut-off lighting with low glare and spill light; utilize downward light fixtures with low-pressure sodium vapor lights.
	10.	Minimize use of safety lights for active aircraft areas near the airfield (includes blinking, intermittent lights, red or white).
	11.	Minimize use of portable lighting; when used, shield portable lighting and angle toward the north.
Linear Contrasts	12.	Use a “corridor” approach to parallel existing linear facilities and minimize the introduction of new linear alignments.
Other Mitigation	13.	Water the main access road, secondary access road, and other on-site unpaved roads during construction to control fugitive dust.

4.9.1.4 Minimal SRS Infrastructure Alternative

Visual impacts for this alternative generally would be less, given the reduced profile of the SCCF and FOCC buildings. Impacts also would be lower under this alternative because the cryogenic fuel plant would be eliminated; however, storage tanks would remain.

Reducing the size and scope of the infrastructure would lessen—but not totally eliminate—potential visual impacts of the project. Some permanent structures would be replaced by temporary structures (office trailers) that present a different set of visual concerns, but generally would be less intrusive with a lower, less prominent profile. The largest single reduction to visual impacts would occur from eliminating the cryogenic fuel plant. However, the impacts of the storage vessels still may require mitigation. The project's size and concomitant impacts would not change materially.

4.9.1.5 Overall Impacts

Due to the clustered nature of the development of the proposed SRS components, the remote location, and generally undistinctive scenery of the setting, the proposed SRS project would have an overall moderate to low impact on visual resources. The cumulative visual impact of past, present, and reasonably foreseeable future actions would be affected almost exclusively by the proposed SRS project. No other development proposals are identified at this time. This, coupled with the currently undeveloped nature of the proposed SRS project location, minimizes any cumulative visual impacts.

Contemplated actions associated with the proposed SRS project include the extension of water, gas, and electricity lines into the SRS area. The water pipeline and related pumphouses from Elephant Butte to the L7 Ranch would have a moderate to low visual impact mostly caused by the addition of several pumphouses. Most of the pipeline would be underground in an already disturbed area. The gas line would originate from the existing gas facilities at Rincon into the SCCF area paralleling the road right-of-way. This also would have a low impact due to the underground placement of the line. The electrical transmission line would start at existing electrical facilities at Rincon. The power line would cross I-25 near the Upham exit and would be parallel to the existing main access road to the SCCF area where it would terminate at a substation with transformer equipment enclosed by a chain-link fence. The visual impact would be high from the I-25 crossing and from the main access road.

4.9.2 RECREATIONAL RESOURCES

Potential recreation and tourism impacts of the proposed SRS project are addressed in this section. The assessment identifies the impacts to recreation in the area of the proposed SRS project and the impacts to existing recreation and tourism in the areas surrounding the proposed SRS. Impacts related to construction and operations workers and tourist visitors related to the proposed SRS also are discussed.

4.9.2.1 Proposed Action

Table 47 summarizes the potential impacts from construction, operation, and visitors associated with the proposed SRS as it relates to recreation and tourism.

Table 47. Potential Impacts on Recreation and Tourism

Activity	Impact
Construction worker use of existing campgrounds	Low
Operation workers use of recreation and tourist facilities	Low
SRS visitor-related pressures on recreation and tourist facilities	Low
Restricted public access to the area for recreation	Low
Reduction of the solitude recreation experience of recreation users due to increased use of the area	Moderate
Increased demands for hunting and wildlife management	Low
Increased access to El Camino Real resulting in possible disruption of the trail and theft of artifacts	Low
Night lighting during routine operations at the proposed SRS	Low
Intense outdoor lighting during night preparation for launches	Moderate

Overall Impacts and Additional Projects

There are no other development proposals for the area. The cumulative impacts on recreation and tourism largely would be driven by the proposed SRS project as no other activities take place at the site. This, coupled with the undeveloped nature of the SRS location would minimize any cumulative impacts. The SRS would enhance the already existing space-related tourist facilities in the area and would increase the overall attraction of the area to this type of tourism.

Effects of the extension of water, gas, and electricity lines from outside of the study area must be considered. The water pipeline from Elephant Butte generally would follow an existing road, and gas and electricity lines would be extended from Rincon across I-25 and would follow the existing access road. No additional cumulative impacts are anticipated because the utility extensions would follow existing roads and would not displace recreational activities or open new areas. Impacts to special seasonal events would be too minimal to allow credible analysis or characterization.

Measures to Reduce Impacts to Recreation

Effects of the proposed SRS on recreation would be minimized because approximately only 7% of the land would restricted from public access. El Camino Real would be protected in the vicinity of the SRS. A visitor center would provide information about the SRS and El Camino Real. Impacts on amateur astronomers would be minimized by using low-impact security lighting and by using intense outdoor lighting only when necessary.

4.9.2.2 No Action Alternative

Under this alternative, there would be no effect on recreation.

4.9.2.3 Minimal SRS Infrastructure Alternative

Under this alternative, the land area withdrawn from potential recreational use would be the same as under the proposed action. Because some of the facilities would not be constructed, the quality of the recreational experience might be higher. The impacts from increased tourism at the SRS would be the same. Overall, the effects of this alternative would be similar to those of the proposed action.

4.9.2.4 Section 4(f) of the Department of Transportation Act

Section 4(f) of the Department of Transportation Act (49 U.S.C. §303(c) provides that no transportation program or project may be approved by the Secretary of Transportation that requires the "use" of publicly owned land of a public park, recreation area, wildlife or waterfowl refuge, or historic site of national, state, or local significance unless there is no feasible and prudent alternative, and all possible planning is accomplished to minimize harm resulting from the use.

The proposed SRS project region includes four State parks, two national wildlife refuges, one national monument, one State monument, and local county or municipal parks and recreation sites (Subsection 3.9.2.2, beginning on page 157, and Figure 27, on page 155). The only historic site of potential local, State, or national significance is El Camino Real, which traverses the western portion of the immediate project area (Figure 21, on page 130). The San Andres National Wildlife Refuge is situated 24 miles southeast of the proposed SRS facilities at its closest point. The nearest State park, Caballo Lake State Park, is 21 miles west of the proposed SRS site. The Bosque del Apache National Wildlife Refuge is approximately 50 miles north.

As shown in Figure 20 on page 125, El Camino Real parallels the AT&SF line for the entire distance through the proposed SRS site and occupies the railroad right-of-way in some sections. It also parallels the existing access road from I-25 for about half the distance through the site. An existing 345-kV El Paso Electric Company transmission line runs north-south through the proposed site and is visible from El Camino Real. Thus, portions of El Camino Real already have been affected by past construction activities and natural water and wind erosion that are unrelated to the proposed SRS (Subsection 4.6.1, beginning on page 237).

Under the proposed SRS development plan, El Camino Real would be crossed near Upham by an improved access road, together with the proposed powerline and natural gas pipeline in the same right-of-way, and crossed again near Aleman by the proposed water supply pipeline (Figure 10 on page 57). However, construction of the powerline, natural gas pipeline, and water pipeline has not yet been determined.

El Camino Real has been studied by the National Park Service as a candidate National Historic Trail under provisions of the National Trails System Act Amendments of 1983 (16 U.S.C. §1241 *et seq.).* To date, 13 National Scenic and National Historic Trails have been designated under the Act, and 30 are subject to consideration for designation (including the Santa Fe Trail in New Mexico). El Camino Real in New Mexico is not on the list of trails identified in the Act for designation or consideration. (An El Camino Real in Florida is under consideration.) There are no current plans by the National Park Service, through the Secretary of the Interior, to initiate a request for Congressional action. Federal legislation would be required because a national historic trail can be established and designated only by an Act of Congress (16 U.S.C. §1244). It is possible that a bill will be introduced in the Congress to designate El Camino Real as a National Historic Trail sometime in the future.

It is also possible that, at some time in the future, the New Mexico SHPO might apply to the Secretary of the Interior for an action that would certify certain lands as protected segments of El Camino Real [16 U.S.C. 1242(a)(3)]. It is also possible that the SHPO would recommend that El Camino Real be included in the National Register of Historic Places. There are no current plans on the part of the State of New Mexico to seek such certification or inclusion.

Nevertheless, the NMOSC and the NMSLO would coordinate management and protection of cultural resources found at the proposed SRS site, including El Camino Real, with the SHPO, the New Mexico Historic Preservation Division, the BLM, and the Advisory Council on Historic Preservation. The National Park Service would be consulted as appropriate. Also, NMSLO resource management plans would provide for protection of El Camino Real through consultation with the appropriate State and federal agencies (Subsection 4.8.2.1, beginning on page 258). This would include maintaining a quarter-mile "buffer" zone on each side of the trail as now provided in the BLM Caballo RMP (Subsection 3.8.2.2, beginning page 144). Mitigation measures would include protective fencing in appropriate locations and inspection of potential disruptive construction activities. Proposed SRS structures would also be designed to minimize visual impact (Subsection 4.9.1.2, beginning on page 268, and Subsection 4.6.1, beginning on page 237).

For the reasons stated, no existing public park, recreation area, wildlife or waterfowl refuge, or historic site determined by Federal, State, or local officials to be "significant" would be physically taken, used, or occupied by the proposed SRS so as to substantially impair their value. In view of the railroad, the existing access road, and other disturbances on and in the immediate vicinity of El Camino Real, the minor road and pipeline crossings would not substantially impair the trail's historical significance. If El Camino Real is designated as a National Historic Trail at some future date, all possible planning would already be in place to minimize any harm resulting from the construction and operation of the proposed SRS. Therefore, the Section 4(f) restrictions would not apply.

The only effects of proposed SRS operations on parks, recreation areas, and wildlife/waterfowl refuges would be from occasional noise associated with vehicle launches. Possible effects on these resources from increased visitation associated with SRS vehicle launching operations is not possible to determine at this time (beginning on page 175 is an unnumbered subsection discussing of the use of incomplete or unavailable information). However, these impacts would be minor and would not substantially impair the use of these facilities.

4.10 SOCIOECONOMIC CONDITIONS

This section describes the potential impacts to population, the economy, employment, tourism, recreation, housing, transportation, traffic, and community services. For purposes of this analysis, the study area is defined as the counties of Sierra and Doña Ana. Peripheral analysis is provided for the outlying counties of Lincoln, Luna, Socorro, and Otero. The analysis incorporates the following assumptions and methodologies:

- The peak construction work force for the full-scale proposal was estimated to be no more than 300 at any one time (NMSU 1995). Of new jobs created, approximately 70% would be filled by workers hired from the regional labor force. The remaining 30% would come from nonlocal sources. The economic forecasting model used to predict trends and impacts is based on estimated total expenditures for construction. The resulting forecasts therefore tend to overstate actual employment for high-value facilities.
- Workers from the local labor force would commute daily to the site of the proposed SRS during both construction and operations phases of the project.
- Analysis of the construction phase was completed using multipliers provided by input-output software developed by the USDA Forest Service, in cooperation with the Federal Emergency Management Agency and the U.S. Department of the Interior, Bureau of Land Management. The software closely follows the accounting conventions used in the "Input-Output Study of the U.S. Economy" by the Bureau of Economic Analysis and the format recommended by the United Nations.
- To capture the household effects of labor expenditures directly associated with launches, the analysis incorporated New Mexico Total Multipliers by Industry Aggregation for

output, earnings, and employment. Operational and launch-related expenditures were modeled using the Regional Input-Output Modeling System (RIMSII) (DOC 1981), and their impacts were added to the final labor figures.

- The nonlocal construction work force was estimated to consist of 80% single workers and 20% married workers with families. The operations work force was estimated to be 25% single workers and 75% married workers with families. Population estimates were calculated based on one person per single household and an average 3.5 persons per married household.
- The analysis was divided into distinct construction and operations phases. Construction costs were based upon information provided by the NMOSC. Operational expenditures and launch schedule estimates were taken from the 1995 Governor's Technical Excellence Committee report (NM 1995b). Information on temporary duty personnel, tourism spending, and associated per diem expenses was derived using mid-level estimates from NMSU (1995).

4.10.1 POPULATION

This section of the analysis describes the potential impact of the proposed action on the existing population as determined by increases in new jobs for construction and operation of the proposed SRS, as well as population increases due to tourism. Potential impacts of the two alternate options also are discussed.

4.10.1.1 Proposed Action

Anticipated employment and population increases resulting from development of the SRS site are presented in Tables 48 through 51. The figures represent employment and population impacts related to construction and operations costs including direct, indirect, and induced investment and spending, as well as tourism. Induced spending or employment refers to the expenditures or employment associated with the household. For example, if a construction project brings $10 million new dollars to a community, some families would be likely to place money in savings or investments. This drives household-induced spending. This type of indirect spending can result in additional employment. For purposes of this study, indirect employment and induced employment are calculated together.

Direct local employment induces growth in the local work force, whereas direct nonlocal employment spurs growth based on in-migration. For any work force, related population increases and related effect on the economy and infrastructure are mainly proportional to employment. Because of the size and length of time for development of the full-scale SRS proposal, the analysis is broken down by year.

Construction

Based on a conceptual, typical construction schedule (NM 1995b), the greatest impact to employment would occur during the second year of construction. This is a reflection of the normal construction schedule for large projects where certain higher cost activities occur in the second year.

The resultant forecasted direct employment total of 1,415 occurs in Year Two (1999). This number is the result of an economic forecasting model that uses total estimated construction costs as the most significant input. Assembly of the high-value cryogenic fuel plant would require relatively little labor because it would be prefabricated off site. Consequently, the forecasted direct employment from the model is significantly higher than that predicted in NMSU (1995) and thus represents the upper boundary on construction-related employment.

An estimated 313 (Year One), 1,705 (Year Two), 478 (Year Three) new jobs would be created locally as an indirect result of construction employment. These new jobs likely would fall within the service and retail sectors but would include a variety of traditionally higher-paying technical positions as well. Induced employment would result from an increase in household spending and savings.

Population figures from Table 49 show that second-year construction would result in the increase of 1,404 new people to the regional population, a 0.8% increase in the 1994 joint population estimates for Sierra and Doña Ana counties.

The population growth predicted above would be distributed in the area in proportion to vacancies in existing housing. Since construction is fairly short term, the number of

Table 48. Employment by Year During Construction, 1998–2000

	Direct	Indirect	Induced	Total
Year One (1998)				
Local	203	184	35	422
Nonlocal	87	79	15	181
Total	290	263	50	603
Year Two (1999)				
Local	991	1,014	179	2,184
Nonlocal	424	431	81	936
Total	1,415	1,445	260	3,120
Year Three (2000)				
Local	284	284	51	619
Nonlocal	122	120	23	265
Total	406	404	74	884

Data Source: Bureau of Business Research & Services, New Mexico State University

Table 49. Estimated New Population During Construction, 1998–2000

	Household Type		
	Single	Married (times 3.5)	Total
Year One (1998)	145	127	272
Year Two (1999)	749	655	1,404
Year Three (2000)	212	186	398

Data Source: Bureau of Business Research & Services, New Mexico State University

vacancies in mobile homes was used as the guide for distribution of increased population during construction. Truth or Consequences, with a 12.3% vacancy rate, would experience an increase of approximately 173 people. Hatch has a 1.2% vacancy rate and would experience an increase of 17 people. Las Cruces has 8.6% of the two-county area vacancies with a resultant increase in population of approximately 121 people in Year Two of construction. The remainder of the construction-related new population would be distributed throughout the unincorporated portions of the two-county area. In Sierra County, 36.5% of the remaining vacancies would produce housing for 399 people. In Doña Ana County, 63.4% of the remaining vacancies would produce housing for 694 people. These increases over the 1994 population amount to 2.7% at Truth or Consequences, 1.3% at Hatch, 0.2% at Las Cruces, and 0.6% for the remainder of the two-county area.

Operations

Employment estimates are provided for project Years Four (2001) through Ten (2007) and are based upon launch schedule and cost estimates from the GTEC report (NM 1995). The estimates include tourism-related employment. Year Ten and subsequent years represent a steady-state operating schedule. The employment figures include permanent and temporary personnel associated with each scheduled launch.

During the operations phase of the proposed project, new employment estimates would be dependent on the number of scheduled launches and projected tourism. On-site operations of the proposed SRS would require a baseline staffing level of approximately 95 employees. Temporary duty personnel assigned to individual launches would have the effect of raising the work force during launch activities.

Maximum employment, and therefore maximum indirect employment related to the operations phase of the proposed SRS, is expected to occur beyond the ninth year and result in 1,052 jobs. Maximum population impacts also would be expected to occur beyond Year Nine (2006) with a projected increase of 909 people.

Operational-related increases in population were distributed using total housing vacancies in the two-county area with percentage allocations of Truth or Consequences at 13%, Hatch at 1%, and Las Cruces at 31%. Using Year Ten as an indicator of long term population, the increases in these areas would be 118 in Truth or Consequences, 9 in Hatch, and 282 in Las Cruces. The remaining population increase of 500 would be distributed across the two-county area.

Table 50. Estimated Operations Employment, 2001–2007

		Est. No. of Launches	Direct	Indirect & Induced	Total
Year Four	(2001)	5	300	462	762
Year Five	(2002)	10	74	374	448
Year Six	(2003)	20	127	696	823
Year Seven	(2004)*	20	266	746	1,012
Year Eight	(2005)	25	350	515	865
Year Nine	(2006)	25	376	525	901
Year Ten	(2007)	30	431	621	1,052

* Year Seven reflects the maximum yearly projected tourism spending in the region.
Data Source: Bureau of Business Research & Services, New Mexico State University

Table 51. Estimated New Population During Operation, 2001–2007

		Household Type		
		Single	Married (times 3.5)	Total
Year Four	(2001)	58	600	658
Year Five	(2002)	34	352	386
Year Six	(2003)	62	649	711
Year Seven	(2004)*	76	798	874
Year Eight	(2005)	65	683	748
Year Nine	(2006)	68	711	779
Year Ten	(2007)	79	830	909

* Year Seven reflects the maximum yearly projected tourism spending in the region.
Data Source: Bureau of Business Research & Services, New Mexico State University

Tourism

Because this operation will be the first of its kind in this region, tourism is expected to be relatively high for initial launch and landing operations but will decrease substantially over a period of time. Scientifically credible estimates of the numbers of tourists, and accompanying impacts, are not possible. Estimates from various industry sources range from 12,000 to 900,000 annual visitors. The estimated economic impacts from these sources were measured by multiplier factors with equally divergent results. Several factors contributing to this variance are discussed in this subsection. The GTEC estimate of approximately 1,000 visitors per launch was used to provide a reasonable approximation of the minimum steady-state economic impacts (NM 1995b).

Current visitor levels for other national space attractions show a similar variation. The visitor levels for activities involving the launch and recovery of space vehicles as reported in NM (1995b) are

- Kennedy Space Center — 15,000 per Space Shuttle launch, 120,000 per year, approximately 30% of which are invited visitors
- Edwards Air Force Base — 2,000 per Space Shuttle landing
- Cape Canaveral (Patrick AFB) — 1,000–5,000 per large ELV launch (primarily invited industry guests)
- Vandenberg AFB, California — 20 to 500 invited guests and an estimated 100 to 200 roadside visitors per ELV launch

The GTEC report (NM 1995b) notes that manned space vehicle launches are far more popular than unmanned launches. The report also states that none of the existing visitor centers at these locations recapture their cost of operation.

Space-related activities with museum facilities were better attended. The numbers of visitors for various locations are

- Space Center Houston — 700,000 per year
- U.S. Space and Rocket Center (Huntsville, AL) — 500,000 per year
- Kansas Cosmosphere and Space Center (Hutchinson, KS) — 350,000 per year
- Air Force Space and Missile Museum (Cape Canaveral, FL) — 175,000 per year
- Space Center (Alamogordo, NM) — 190,000 per year

The data relative to tourism at established national space-related attractions is not credible for estimating the level of visitor activity at the proposed SRS. The established facilities and the proposed SRS are different in nearly every respect. To illustrate the differences, the following examples are given:

- The Kennedy Space Center is operated by NASA for manned space flight activity. NASA programs are funded from Federal budget sources and depend on a broad base of public acceptance for sustaining funding. NASA attempts to attract visitors, even at a loss, to increase public support. The SRS would be a private, commercial operation depending on the generation of profitable return on the investment for its continued existence.

- Established facilities are located in areas with attractive climate and setting. The SRS would be located in a harsh setting, which can be hostile during the summer.
- Established facilities are located in close proximity to major population centers with numerous, large and diverse tourist attractions unrelated to space activity. The SRS would be isolated and in an area without significant additional tourist attractions.
- Kennedy Space Center and Cape Canaveral provide extensive visitor facilities and attempt to attract visitors. The SRS would limit facilities and control visitor access.

Some level of visitor activity is inevitable; however, the SRS would not actively promote this activity. As noted in Subsection 2.1.6, beginning on page 47, the SCCF would have provisions for a small visitor center that would be available for casual visitors during nonoperational periods. There would be no other dedicated facilities, and casual visitors would not be allowed in the RLV operations or airfield areas. RLV flight operations would be publicized in the local area as a noise mitigation measure, but there would be no widespread advertisement of anticipated activities.

During periods of operational activity, access to the SRS area would be controlled by limiting access at the I-25 and NM 51 entry points. Traffic would be controlled along I-25 to provide for public safety. Both invited and casual visitors allowed into the SRS area during operations would use existing SCCF facilities for catering, parking, and lavatories and would not be allowed unrestricted access to interior areas of the SRS.

Data pertaining to visitor activity was compiled by the GTEC Tourism Assessment Committee and included in NM (1995b) as Appendix E. This data has been extracted and attached to this document as Appendix G. Other estimates of visitor activity and accompanying impact is purely speculative. Beginning on page 175 is an unnumbered subsection discussing of the use of incomplete or unavailable information.

4.10.1.2 No Action Alternative

Under this alternative, the impacts described in Subsection 4.10.1.1, beginning on page 277, would not occur. No increase in population due to the in-migration of construction workers or operations employees would take place. Employment opportunities related to construction and operation would not be enhanced. This alternative would not lead to increased use of community services nor would it increase the need for temporary or permanent housing. No property taxes, sales taxes, or gross receipts taxes would be derived from SRS-related property.

4.10.1.3 Minimal SRS Infrastructure Alternative

Under this alternative, employment would be reduced proportionate to the remaining costs of construction. Tourism per launch/landing event would be the same as the proposed action.

4.10.2 ECONOMY

This section describes potential impacts to the local economy of the proposed action and the two alternatives. Topics include sectoral growth and employment.

4.10.2.1 Proposed Action

The principal economic effect of SRS development as proposed would be an increase in employment associated with construction and operation. Indirect growth in employment would occur in the service and retail sectors with some growth in local technical trades. Under the proposed action, new businesses designed to provide general and technical services to the SRS site operations would be likely to open. Other businesses would expand to meet the stronger demand for goods and services.

An increase in technical and professional jobs—in addition to short-term construction employment—would invigorate the economy of Sierra County, which currently reports sluggish growth and moderate unemployment rate (5.5%). The larger municipality of Las Cruces would feel a slight increase in personal income and related expenditures. Unemployment in Doña Ana County (8%) would be reduced.

Average household spending likely would increase in Sierra County as households now report relatively low spending (1990 Census). Doña Ana County household spending would be unlikely to show any change as the county reports a relatively high number of government employees and individuals employed in the services sector.

Construction

Construction-related economic growth would be a function of expenditures, direct employment, indirect employment, and induced employment. The largest of these effects would be in Year Two of construction.

Operations

Economic growth during the operations phase would become a function of expenditures per launch, launch-related tourism, and total employment. The long-term effect of operating the proposed SRS would be seen in Year Ten, which represents the operations at maximum launch capacity. This situation is projected to provide 1,052 jobs based upon estimated direct expenditures of $36.5 million.

Tourism

In addition to worker-related effects on the economy, tourism is expected to have an effect. This effect would be concentrated in Truth or Consequences, Caballo Lake area, Hatch, and Las Cruces. The effects would be felt due to direct tourist expenditures and indirect and induced economic activity.

Once steady-state operations were reached (30 flights per year), the effects of tourism per year are shown in Table 52.

Table 52. Tourism Effects

Location	No. of Tourist Days	Direct Tourist Expenditures	New Job Creation	Total $ Effects
Truth or Consequences	388	$225,245	12.6	$399,562
Caballo Lake	90	$47,887	2.5	$84,947
Hatch	4	$3,547	0	$6,292
Las Cruces	416	$322,792	18.1	$572,472

No Action Alternative

This alternative would result in no increase in employment opportunities or the potential for growth in the service and retail sectors (Subsection 4.10.1.1, beginning on page 277).

Minimal SRS Infrastructure Alternative

Compared with the proposed action, this alternative would result in a smaller increase in employment opportunities and sectoral growth in proportion to the reduction in project construction costs. Household spending and investment would be reduced.

4.10.3 HOUSING

This section describes the potential impact on the availability and cost of housing of the proposed action. It includes a discussion of the impact on housing of the two alternative proposals.

4.10.3.1 Proposed Action

Construction

Housing estimates are based on population for the second year. Second-year housing needs show the greatest impact with 749 household units required for single individuals and 187 units needed for families (average 3.5 persons per household).

Using the logic presented for the distribution of construction population, the number of mobile units to be occupied would be 125 (13%) in Truth or Consequences, 2 (<1%) in Hatch, and 85 (9%) in Las Cruces with the remainder of the two-county area supplying 730 units. This increased occupancy would reduce the vacancy rate in each area by slightly less than 50% of the available units. This would suggest a positive impact with little upward pressure on rents.

Operations

Table 53 shows estimated housing needs based on direct, nonlocal employment for project Years Four through Ten.

Table 53. Estimated Housing Need During Operation, 2001–2007

		Household Type		
		Single	Married (times 3.5)	Total
Year Four	(2001)	23	67	90
Year Five	(2002)	6	16	22
Year Six	(2003)	10	28	38
Year Seven	(2004)	20	60	80
Year Eight	(2005)	26	79	105
Year Nine	(2006)	28	85	113
Year Ten	(2007)	32	97	129

Data Source: Bureau of Business Research & Services, New Mexico State University

No Action Alternative

Under this alternative, the impacts described in Subsection 4.10.3.1, beginning on page 286, would not occur. No increase in population due to the in-migration of construction workers or operations employees would take place. Employment opportunities related to construction and operation would not be enhanced. This alternative would not lead to increased use of community services nor would it increase the need for temporary or permanent housing. No property taxes, sales taxes, or gross receipts taxes would be derived from SRS-related property.

4.10.3.2 Minimal SRS Infrastructure Alternative

Under this alternative, the need for housing would be smaller in proportion to the reduction in costs during both construction and operation phases of the project.

4.10.4 COMMUNITY SERVICES

This section describes impacts on community services of the proposed action. Topics include impacts to police, fire, schools, and medical services. Additional information is provided on impacts to community services based on the two alternatives.

4.10.4.1 Proposed Action

Law Enforcement Officers

Requirements for additional law enforcement officers as a result of SRS construction and operations would be applicable only to Las Cruces. Based on the existing ratio of law enforcement officers per 1,000 persons, Las Cruces would need to add two officers for Year Two of construction and one officer after operations begin. Truth or Consequences, Hatch, Sierra, and Doña Ana counties would not require additional law enforcement officers. These estimates do not account for the need for additional law enforcement officers based on normal predicted population growth.

Fire

The 387-square-mile area of the proposed SRS site currently is served by volunteer fire departments in Garfield and Rincon. A volunteer fire department in Hatch serves as backup in some circumstances. It currently is unknown if construction of the proposed SRS would have an impact on these volunteer fire departments as construction plans includes on-site fire prevention and response. The SRS fire response crew would be responsible for fighting structural and wild fires within the SRS and would serve as backup to the volunteer fire departments in Rincon and Hatch.

No impact is predicted for fire departments in Truth or Consequences or Las Cruces because these departments would be relatively well equipped, funded through a 0.25% set aside in revenues from New Mexico gross receipts tax.

Schools

Under existing conditions, Sierra and Doña Ana county schools would see enrollment increases in existing student totals during construction and operation of the proposed SRS. Table 54 provides estimates of new student enrollment based on this proposed action.

During the first year of construction, it is assumed that 38 school-aged children would be absorbed into Sierra and Doña Ana counties' schools. Second-year construction estimates, however, would pose a significant increase in school-aged children and would impact already crowded schools in Truth or Consequences, Hatch, and Las Cruces schools. During operations of the SRS, the permanent increase in population and employment would result in a larger tax base and increased operation revenues for the school districts. The most significant positive impact would be the increased revenues from the State

Trust Land that would be distributed to the New Mexico school system. The lease fee for the SRS State Trust Land cannot be estimated at this time; therefore, the positive impacts for the school systems are too speculative. Public Law 103-397 provides that Payments in Lieu Taxes (PILT) to Sierra and Doña Ana counties would continue after land exchange. Consequently, the only loss of tax revenue to the counties would approximately $6,500 generated by the Sierra County Chattel Tax, a tax on each head of livestock.

Medical Services

The proposed action would have an impact on existing medical services in Sierra County as Truth or Consequences attracts few doctors and other health care personnel. As a result of the shortfall in health care workers and facilities in Sierra County, many new workers likely would seek medical care in Las Cruces, which has a larger number of physicians and health care providers per capita. The existing capacity of the Las Cruces health care system could absorb the increase in demand.

4.10.5 TRAFFIC IMPACTS

This section describes the potential impacts of the proposed action on traffic in Sierra and Doña Ana counties. The impacts were calculated based on construction and employment

Table 54. Estimated New Student Enrollment, 1998–2007

Project Year	Total Children	School-aged Children[1]	Grade Level	Sierra Cty. Schools	Doña Ana Cty. Schools
Year One	54	38	K–5	6	13
			6–8	2	6
			9–12	3	8
Year Two	281	197	K–5	29	67
			6–8	13	31
			9–12	17	40
Year Three	80	56	K–5	8	19
			6–8	4	9
			9–12	5	11
Year Four	257	180	K–5	26	61
			6–8	12	28
			9–12	16	37
Year Five	151	106	K–5	15	36
			6–8	7	17
			9–12	9	22
Year Six	278	195	K–5	29	66
			6–8	12	31
			9–12	17	40
Year Seven	342	239	K–5	35	80
			6–8	16	38
			9–12	21	49
Year Eight	293	205	K–5	30	69
			6–8	14	32
			9–12	18	42
Year Nine	305	214	K–5	31	72
			6–8	14	34
			9–12	19	44
Year Ten	209	146	K–5	21	49
			6–8	10	23
			9–12	13	30

1 Based on estimated 70 percent of total children at school age.

Data Source: Bureau of Business Research & Services, New Mexico State University figures, estimated miles traveled, and traffic statistics provided by the New Mexico State Highway and Transportation Department (NMSH&TD 1995). Increased activity from construction and operations, as well as impacts from tourism and new employment, were considered under this section. Environmental effects, such as air quality and noise, are discussed within each individual section.

The proposed SRS access and internal roads are projected to have an average volume of 300 vehicles per day making round trips at average speeds of 55 mph on paved segments of road and 25 mph on unpaved segments. The only Federal and state highways in the area are I-25, located 15 miles south or 25 miles northwest and NM 51, which is approximately 21 miles northwest. When compared with these highways, the projected SRS levels of use are not expected to be sufficient to cause potentially significant impacts on the environment.

4.10.5.1 Construction Phase (1998–2000)

The construction phase of the proposed action would impact traffic on I-25 and nearby access roads as construction workers, tractor trailers, and other large vehicles travel to the construction site. The greatest traffic impacts would be expected to occur between the hours of 7:00–9:00 a.m. and 4:00–6:00 p.m. Peak traffic hours measured north of Exit 9 on I-25, 26 miles south of the Upham Exit, occur at 3:00 p.m. with 250 vehicles an hour traveling north and at 5:00 p.m. with 210 vehicles traveling south. During the most intensive stage of construction, estimates of the number of motorized vehicles commuting daily to the site range between 250 and 350. The impact would be to increase the current volume of morning and afternoon “rush hour” traffic on I-25 between Hatch and Las Cruces by 60% to 85%. The impact of traffic would be felt mostly by residents living north of Las Cruces. The community of Hatch is far enough away from I-25 that traffic impacts would result only from those who actually settle within the village, approximately 17 people. This would result in approximately 34 additional vehicle passages per day.

4.10.5.2 Operations Phase (2001–2007)

Estimates of traffic impacts of SRS operation were based on full-scale launch activities estimated for the year 2007. The greatest impact again would be on I-25 as permanent staff, visiting personnel, commercial vehicles, and tourists arrived to prepare for or witness approximately 30 launches annually. On days without scheduled launches, approximately 150-200 vehicles per day with 1.7 people per vehicle would commute to the site. On days with scheduled launches, launch spectators would add an additional 200–250 vehicles with 2.2 people per vehicle. These figures were based on an estimate of 500 staff members and 25 temporary-duty personnel per launch who would be allowed access to the area.

The average commuting distance for staff and temporary-duty personnel is estimated to be 53 miles with the majority of workers commuting to and from Las Cruces. The average commuting distance for commercial and tourist traffic would be 78 miles. Commercial and tourist traveling distances would be higher because it is expected that commercial traffic and tourist from northern New Mexico and El Paso/Juárez would travel greater distances to conduct business or observe a launch.

4.11 ELECTROMAGNETIC RADIATION

Electromagnetic radiation from SRS activities has the potential for interference with radio astronomy observing at the VLA radio telescope located west of Socorro, New Mexico, approximately 100 miles northwest of the SRS location. New uses at the SRS of VLA observing frequencies as shown in Table 31, on page 174, could adversely impact astronomy programs.

The proposed SRS would not require extensive equipment that would emit EMR. The space vehicles to be launched from the facility are not envisioned to require new types of communications systems or tracking by powerful radars. None of the communications equipment to be used at the SRS, either ground-to-space or local within the SRS, would use frequency bands that currently are in use for observation at the VLA. The potential for electromagnetic interference effects with the VLA, or with any other established spectrum user including the NASA TDRSS ground station, is considered minimal.

Much of the guidance information that has traditionally been provided to ground controllers via radar can now be provided using global position system receivers in the vehicle with the data relayed to the ground-using frequencies already reserved for telemetry. The power that must be radiated is orders-of-magnitude lower with this new method. Because use of these new technologies is a requirement of the NASA X-33 program, it can be assumed that commercial derivatives and other new RLVs would incorporate similar technology (NASA 1996a). (Radar tracking, if required for specific missions, may be provided by existing systems on WSMR.) Any use of the radio spectrum would occur only after proper licensing with the Federal Communications Commission and coordination with the Area Frequency Coordinator who ensures that frequencies reserved for Federal use are properly managed.

4.12 CUMULATIVE IMPACTS

"Cumulative impacts" are those environmental impacts which result from the *incremental* effects of the proposed action when added to other past, present, or reasonably foreseeable future actions (40 CFR §1508.7). Cumulative impacts can result from actions which are individual minor but collectively significant.

The proposed SRS project area does not currently have, nor has it had in the past, any type of industrial development other than a railroad, several electrical transmission lines, and a cross-country natural gas pipeline. Although there has been some sporadic mining activity, the prevailing land use has been agricultural. With or without development of the proposed SRS, the effects of livestock grazing, limited mineral extraction, and associated ancillary uses would continue to accumulate. There are no other development proposals for the area. All land-use management plans for public and State Trust land specify continued current use for the foreseeable future. Any unofficial discussion of future development is highly speculative and conjectural. Therefore, any cumulative impacts from future development at the proposed SRS site would be those impacts resulting from the project itself. Although the SRS may attract other types of aerospace-related industrial development in the future, any projections of the extent of such development would be strictly speculative. Because of the higher level of maturity of the aerospace industry at the present time compared with the developmental period of other launch facilities, and because of significant demographic differences, comparable development associated with these facilities is not expected at the SRS. Beginning on page 175 is an unnumbered subsection discussing of the use of incomplete or unavailable information.

As discussed in Subsection 2.1.6.7 beginning on page 66, the State is in the process of completing engineering designs and negotiating with potential suppliers for utilities outside SRS boundaries. To the greatest extent practicable based upon conceptual design, this EIS will include information about potential impacts of the proposed and alternative routings for utilities, including cumulative impacts. Construction will not commence until appropriate environmental review is completed and applicable permits have been issued. While the electric transmission line would have cumulative visual impacts, this line and the water and natural gas pipelines generally would follow existing road rights-of-way so as to minimize cumulative land disturbance.

The following discussion addresses potential cumulative effects of the SRS project according to the environmental attributes discussed in Sections 3.0 and 4.0

- Occupational health and safety. Illnesses, injuries, and fatalities resulting from routine SRS construction and operations activities would accumulate throughout the life of the project. There is no reasonably foreseeable future industrial activity that would enlarge these effects. Cumulative effects associated with accidents and abnormal events are not possible to predict.
- Public health and safety. There are no predictable effects associated with SRS development that would cumulatively impact public health and safety. Any cumulative effects associated with increased tourist visitations (e.g., visitor vehicle accidents) are highly speculative.
- Surface water. Intermittent surface water, ephemeral streams, and floodplains would not be adversely or cumulatively affected.
- Groundwater. Groundwater quality is unlikely to be adversely affected. However, draw down of underground water supplies for SRS needs could have some long-term cumulative effect if underground formations containing groundwater were not adequately recharged. There is not enough information to predict the degree of draw down, but depth to groundwater and water quality would be measured during production.
- Air quality. With the exception of fugitive dust, air emissions would be widely dispersed and would not produce cumulative effects. Cumulative effects of fugitive dust would be confined to effects on plants and animals from roadside dust associated with unpaved roads.
- Biological resources. Habitat removal and disturbances created by human activities (e.g., noise) would have cumulative effects on biological diversity in the immediate areas of SRS facilities. Effects on bird roosting, nesting, foraging, breeding behavior, and reproduction would be cumulative and some species would probably migrate from operations areas where there were continual disturbances. Bird species covered by the MBTA would be affected although disturbance of these species would not constitute an MBTA "taking." Some exotic bird species more tolerant of human activity would probably immigrate to the area over time. Cumulative effects on mammals is difficult to predict although large mammals (e.g., deer and antelope) would migrate to locations removed from major areas of SRS activity. Effects on plants would generally be confined to the construction period and would not be cumulative. The effects of eliminating cattle grazing on the 27 sections of the Exclusive Use Area constitutes a beneficial cumulative impact. Both the USFWS (1996b) and New Mexico Department of Game and Fish (personal communications: Bob Wilson) have requested the initiation of intensive, long term

habitat studies to evaluate the effects of the elimination of grazing. The NMSLO has taken these requests under advisement.

- Cultural resources. Impacts would be confined to the construction period and would not be cumulative due to the employment of the mitigation measures identified.
- Noise. Occupational noise effects would not be cumulative unless workers disregarded the use of hearing protection when and where required. Except for launch and sonic boom noise, there would be no noise associated with the project audible outside the site. There are no current or foreseeable activities that would result in significant cumulative noise effects outside the SRS because of the infrequency and short duration of noise events. Noise impacts on wildlife would not be cumulative because animals exposed to noise within the proposed site would either become acclimated to noise disturbances or would leave the area.
- Visual and recreational resources and tourism. In general, effects of SRS construction and operations on visual and recreational resources would not be cumulative unless SRS facilities were expanded or added to in the future. However, visual impacts of the proposed 40-kV electrical transmission line would be cumulative when considering the transmission lines already in existence at the proposed SRS site (Figure 2 on page 12). Any cumulative effects resulting from increased tourist visitations are highly speculative.
- Land use. Agricultural and mining uses would change only slightly to accommodate the proposed SRS and would not be cumulative. Increases in recreational uses (e.g., hunting and ORV use) due to the presence of more workers and visitors in the SRS area would be cumulative. Changes in land use due to residential, commercial, or industrial development would be cumulative although such changes are not capable of prediction.
- Socioeconomics. Worker-related traffic would increase during SRS construction and operations and can be considered as cumulative when added to existing traffic in the proposed SRS area. Tourist traffic might increase cumulatively although the number of visitors that would be attracted to SRS vehicle launches in future years is not possible to predict. Cumulative effects on quality-of-life would generally be limited to periodic short term noise and (unpredictable) increases in tourist traffic.

The three proposed facilities about which detailed information is unavailable (40-kV electrical power line, water distribution system, and natural gas distribution system) would not change this assessment of cumulative impacts. As stated, the proposed electrical power line would have cumulative visual impacts. The three facilities would result in either no or only minor cumulative impacts in terms of land disturbance.

4.13 ENVIRONMENTAL JUSTICE IMPACTS

Executive Order 12898 of February 11, 1996, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations (EO12898 1996) provides guidance for identifying and addressing disproportionately high and adverse effects on minority populations and low-income populations. According to these guidelines, the communities surrounding the proposed SRS area are to be considered minority and low-income population areas (Subsection 3.10, beginning on page 160).

While there are minority and low-income communities near the proposed SRS area, human health and environmental impacts would not fall disproportionately on these communities nor would adverse impacts be appreciably greater than those experienced by the general population in Sierra and Doña Ana counties or in the State at-large. Except for Hatch, the percentage of Hispanics and people living in poverty are fairly representative of the two-county area and New Mexico as a whole. Although Hatch has a high minority population and a high poverty level, the community represents only .08% of the combined population of Sierra and Doña Ana counties. Further, Hatch would be subject to the same human health and environmental impacts as other population groups in the two counties, including minority and poverty-level populations in Truth or Consequences and Williamsburg.

4.13.1 ENVIRONMENTAL JUSTICE BACKGROUND

Although there have been no published uniform standards for evaluating environmental justice parameters, it is generally accepted that a “minority population” exists in circumstances where either

- the minority population of the affected area exceeds 50%
- the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis

“Minority” in the context of EO12898 means “non-white” and includes Black/African Americans, Native Americans, Hispanics, Asians, and others such as Eskimos that do not fall within these groups. “Low-income populations” are defined as those at or below the poverty level established by the U.S. Department of Health and Human Services or those qualifying for the U.S. Department of Housing and Urban Development housing benefits programs.

In determining whether human health effects are "adverse and disproportionately high," three factors are considered

- whether health risks are significant, unacceptable, or above generally accepted norms
- whether the risk or rate of exposure by a minority or low-income population is likely to appreciably exceed the risk to the general population (e.g., population near the SRS area)
- whether health effects occur in minority or low-income populations affected by cumulative or multiple adverse exposures to environmental hazards

Disproportionately high and adverse environmental impacts are impacts on the natural or physical environment (ecological, cultural, economic, or social) that appreciably exceed environmental effects experienced by the general population (or population near the SRS area). Cumulative and multiple adverse exposures must be considered. "Exposures" are defined to mean contacts with hazardous chemical, biological, or physical agents (including noise). Multiple exposures over time at one or more locations must be considered in determining if such exposures are disproportionately high and adverse.

4.13.2 MINORITY AND LOW INCOME COMMUNITIES IN SRS AREA

The non-Hispanic majority in Sierra County is reflected in the local populations of Truth or Consequences, Williamsburg, and the small communities in the vicinity of Engle. The Hispanic majority in Doña Ana County is reflected in the communities of Rincon and Hatch. However, the agricultural and ranching communities of Sierra and Doña Ana counties in the vicinity of the SRS display the lower per capita and family income levels generally associated with agriculture. Additionally, the SRS work force would be comprised of approximately 70% local labor. Considering the ethnic composition of the regional and local areas, people of Hispanic origin would comprise approximately 45% of the construction and operational phase work forces.

From this perspective, the proposed action may have direct, indirect, and cumulative effects on a broad spectrum of minority and low income populations. In general, all of the communities in the vicinity of the SRS are considered as minority or low income communities.

4.13.3 HUMAN HEALTH EFFECTS

The proposed SRS would not create disproportionately high adverse human health effects on minority and low-income populations or others in the general population. The site proposed for the SRS would provide the lowest possible risks associated with space vehicle operations. Waste streams of toxic or hazardous materials would not be generated nor released in quantities that could result in adverse human health effects on the general public. The employment of hazardous materials at the SRS would be no greater than those at other similar industrial facilities, regardless of location. Air pollutants would be generated by various activities including launches, cryogenic fuel production, and miscellaneous activities. The only exhaust product resulting from liquid hydrogen and liquid oxygen vehicle propellants would be water vapor. The air-pollutant generation rates from cryogenic fuel production would not require a Prevention of Significant Deterioration air quality permit as there would be no predicted emissions that would exceed ambient air quality standards. Water runoff and wastewater discharges would be controlled within applicable permit standards. Consequently, there would be no unacceptable exposure to risks of adverse health effects by any population group, on or off site.

4.13.4 ENVIRONMENTAL EFFECTS

Ecological, biological, and physical effects of the proposed SRS construction generally would be confined to the SRS site. The principal environmental effects on the surrounding populations from SRS operations would be noise from launch activities and the socioeconomic impacts from increased population and land-use patterns changes.

Noise Effects

Analyses of the noise background and projected effects are discussed in Subsections 3.7 and 4.7, beginning on pages 135 and 241. The analyses of noise effects were conducted using a launch activity level of 30 launches per year. Operations were assumed to stabilize at this level in Year Ten (2007) (NM 1995b). Each launch would produce a noise event of approximately 93 dBA in the community of Cutter, and approximately 91 dBA at the L7 Ranch, approximately 8 miles northwest of the SRS. These events would have a duration of less than 2 minutes. See Figure 22, on page 136, for a graphic comparison of a sonic event of this magnitude with other noise sources.

Each launch would produce a maximum noise event in Rincon of no more than 63 dBA for less than 2 minutes. This level would be reached under easterly wind conditions that occur less than 10% of the time (Table 11, page 110). The intensity of the noise in Truth or Consequences would be approximately 67 dBA. For people inside buildings in Rincon, these noise events typically would be attenuated an additional 20 dBA to approximately 43 dBA. Launch noise at Rincon would be attenuated so that indoor noise levels would be only slightly above normal.

Noise events of these magnitudes, durations, and repetition rates would have few disruptive effects. The disruptive effects would be mitigated through appropriate public notifications, which would serve to reduce the startle effect of the launches. Furthermore, launches normally would be scheduled during daylight hours because of operational constraints. Night launches seldom would be scheduled. The general population of Rio Grande Valley communities would experience only brief noise events, and day-night average sound levels would not exceed 65 dBA as a result of SRS activity. Consequently, noise events from SRS launch activity would not be considered as a disproportionately high and adverse impact.

Socioeconomic Effects

As discussed in Subsection 4.10, beginning on page 275, the overall socioeconomic impacts on the economy, population, housing, community services, and transportation would be minimal. Negative impacts would occur primarily in Truth or Consequences and Las Cruces and would not occur "disproportionately" in such communities as Hatch and Rincon. From the baseline data presented in "Income and Poverty," beginning on page 163, it is apparent that the Hispanic communities of the Rio Grande Valley in the vicinity of the SRS would experience increased employment opportunities, a general trend for improvement in housing, and a broadened tax base supporting improved community services and infrastructure.

4.14 COMPARISON OF THE IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

The purpose of this section is to summarize and compare the environmental impacts of the proposed action and alternatives analyzed in Subsections 4.1 through 4.12, beginning on page 177. A matrix expressing the impact comparison is provided in Table 55. Because

Table 55. Comparison of Environmental Impacts of Proposed Action and Alternatives

Proposed Action and Alternatives Impact Element	Proposed Action		Minimal Infrastructure		No Action Alternative	
	Short-term[a]	Long-term[b]	Short-term	Long-term	Short-term	Long-term
Public Safety	No impact	Non-detect	No impact	Non-detect	No impact	No impact
Worker Safety	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Topography (Land Form)	Mod adv	Non-detect	Minor adv	Non-detect	No impact	No impact
Soils	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Paleontological Resources[1]	Minor adv	Non-detect	Non-detect	Non-detect	No impact	No impact
Surface Water Resources	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Surface Water Quality	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Ground Water Resources	No impact	Mod adv	No impact	Minor adv	No impact	No impact
Ground Water Quality[2]	No impact	Non-detect	No impact	Non-detect	No impact	No impact
Mineral Resources Extraction[3]	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Air Quality	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Vegetation	Mod adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Wildlife	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Threatened/Endangered Species[4]	No impact	No impact	No impact	No impact	No impact	No impact
Sensitive Species[5]	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Biological Diversity	Minor adv	Minor adv	Minor adv	Minor adv	No impact	No impact
Cultural Resources[6]	Minor adv	Non-detect	Minor adv	Non-detect	Minor adv	Minor adv
Noise	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Private Land Ownership/Use[7]	Major adv	Major adv	Major adv	Major adv	No impact	No impact
Public Land Ownership/Use	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Visual and Aesthetic Resources	Minor adv	Major adv	Minor adv	Major adv	No impact	No impact
Recreation Resources	Minor adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Economy/Employment	Beneficial	Beneficial	Beneficial	Beneficial	No impact	No impact
Housing/Community Services	Non-detect	Non-detect	Non-detect	Non-detect	No impact	No impact
Transportation/Traffic	Mod adv	Mod adv	Minor adv	Mod adv	No impact	No impact
Environmental Justice[8]	No impact	No impact	No impact	No impact	No impact	No impact

Key:

a Short-term means construction period of approximately 2 years plus 6 to 12 months to achieve full operations.

b Long-term means full SRS operations for an indefinite period.

Major adv — Major adverse environmental impact
Mod adv — Moderate adverse environmental impact
Minor adv — Minor adverse environmental impact
Beneficial — Beneficial environmental impact
Non-detect — Nondetectable or immeasurable environmental impact

1 Any paleontological resources would be discovered during construction. Mitigation measures would be used to minimize adverse impacts.

2 No activities are proposed to be undertaken that would affect ground water quality. If there should be such effects, they would be nondetectable.

3 Access to approximately 27 sections of land—approximately 7% of the entire SRS—would have certain restrictions pertaining to mineral extraction. It is assumed that the remainder of the site would be open to mineral development under NMSLO requirements.

4 No Federally-listed or State-listed species of plants or animals have been discovered at the proposed SRS site although two species of cactus were found that were down-listed from the New Mexico endangered species list in October 1995.

5 Sensitive species include Federally or State-listed threatened and endangered species as well as candidate species not yet listed and down-listed species that may be relisted.

6 "Minor adverse impacts" are designated for the no action alternative because prehistoric or historic archaeological sites would not receive tho same degree of protection as under the proposed action. For example, they would not be protected from vandalism or unauthorized removal under the no action alternative.

7 Present private landowners from whom land for the proposed SRS would be acquired are perceived to be impacted significantly although they would be adequately compensated for their land.

8 There would be no disproportionately high and adverse human health or environmental impacts on low-income or minority populations in the area of the proposed SRS. All ethnic and economic groups would be affected, although some would either benefit or be adversely affected more than others.

quantitative data are neither available nor appropriate for some environmental parameters, the comparative analysis is qualitative and based on the professional judgment and experience of the investigators.

4.14.1 ENVIRONMENTAL IMPACT MATRIX USERS' GUIDE

The “key” at the bottom of Table 55 interprets the descriptor abbreviations used in the impact comparison matrix. These descriptors provide for a qualitative comparison of the relative magnitude and time duration of the impacts of the proposed action (Subsection 2.1, beginning on page 10), no action alternative (Subsection 2.2.1, beginning on page 79), and developing a minimal infrastructure for the proposed SRS (Subsection 2.2.2, beginning on page 80). Each descriptor is defined below

- Major adverse environmental impact—meets the definition of the word “significantly” in 40 CFR §1508.27. It considers geographic extent, duration, intensity, and magnitude. Commitments to mitigation measures described in Section 5.0, beginning on page 306, are required.
- Moderate adverse environmental impact—a lesser impact that is generally acceptable and can be easily tolerated or mitigated.
- Minor adverse environmental impact—minute, trivial, inconsequential, or small.
- Nondetectable environmental impact—indicates that the impact is not discernible. Can also mean that the impact is immeasurable by scientifically credible methods.
- No impact—means that the status quo would remain unchanged. It does not mean that leaving things as they are has no environmental impact.

As further guidance for the reader, the impacts of each alternative are summarized below.

4.14.2 PROPOSED ACTION

The impacts of the proposed action are presented in detail in Section 4.0, beginning on page 175. The principal distinction between the proposed action and the minimal infrastructure alternative (Subsection 4.14.4, beginning on page 303) would be the construction of permanent structures and other facilities with associated increases in risks to site workers, soil disturbance, wildlife disruptions, visual intrusions, and noise. However, the greater impacts associated with the proposed action would be primarily during the construction period. The long-term impacts during operations would be virtually the same for the proposed action and the minimal infrastructure alternative.

4.14.3 NO ACTION ALTERNATIVE

Taking no action to establish a SRS at the proposed site simply means preserving the status quo. While there would be "no impact" resulting from the proposed SRS, other types of environmental impacts would continue to occur. For example, wind and water erosion would remain unchanged, and air quality would continue to be affected by particulates and minor vehicle emissions. Impacts associated with livestock grazing, mineral extraction, and outdoor recreation uses would continue at the present rate or perhaps increase in magnitude. Prehistoric and historic archaeological resources would not be identified and protected as they would be with establishment of the SRS.

4.14.4 MINIMAL SRS INFRASTRUCTURE ALTERNATIVE

The major distinctions between the potential impacts of this alternative and the proposed action are associated with four characteristics

- using temporary structures for some facilities
- not building the cryogenic fuel production facility
- not constructing the 40-kV electrical transmission line
- not constructing the natural gas pipeline.

Impacts resulting from soil disturbance, air emissions, and visual intrusions would be less than the proposed action. However, the launch/landing complex, other RLV support facilities, and the airfield would still be required to operate the SRS. If the SRS were technically and financially successful, the minimal infrastructure would eventually have to be replaced with full development.

4.15 ADVERSE IMPACTS WHICH CANNOT BE AVOIDED

Section 5.0, beginning on page 306, summarizes and restates a number of mitigation measures proposed to minimize, rectify, reduce, or eliminate certain adverse impacts over time. However, not all of the impacts identified and analyzed in Subsections 4.1 through 4.12, beginning on page 177, for the proposed action can be avoided altogether. "No action" is the only alternative under which all impacts analyzed would be avoided. As discussed in the previous sections, some impacts would be avoided under the minimal infrastructure alternative (e.g., those associated with construction and operation of the cryogenic fuel plant and the natural gas and electrical transmission lines). The major unavoidable adverse impacts would be vegetation and soil removal, removal or disturbance of wildlife habitat, noise, increased traffic, acquisition of private land, and some changes in the rural quality-of-life.

4.16 SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Although it currently is impossible to predict the life span of the proposed SRS, it would not be a "short-term" use of the environment. The long-term productivity of the natural environment has been progressively altered and reduced in the region of the proposed SRS by human settlement, livestock grazing, mining, and recreational uses for more than a century. While agricultural practices and recreational uses would be altered by the development of structures, roads, and utilities associated with the proposed SRS, historic "productivity" would not be precluded by any short-term uses.

Also, there are long-term benefits to be considered. Development and operation of the proposed SRS would fulfill a number of commercial space exploration and research objectives for the long-term benefit of the world. The space-related research and development opportunities in such areas as biomedicine, energy development, communications, and education would outweigh the small amount of environmental degradation from developing the SRS.

4.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Certain soil, water, and energy resources would be destroyed or consumed in the construction and operation of the proposed SRS. These resources would not be available for other uses and could not be retrieved.

Soil losses due to construction and subsequent erosion in these same areas would be irretrievable losses. Although approximately 1,109 acres would be cleared and graded for construction, much of this would be reclaimed and revegetated. The potential for soil loss resulting from the proposed SRS is small because the total land area that would be disturbed is less than 1% of the land within the SRS boundaries.

Constructing a major spaceport facility and development of ancillary facilities—including roads and an airfield—would alter topography within this portion of the proposed SRS site. Due to permanent changes in topographic character and features and the subsequent long-term changes in vegetative cover and growth patterns, impacts on landscape character and visual resources would result.

Water requirements for the proposed SRS are approximately 1,200 acre-feet per year. If Elephant Butte Reservoir is not used as the source of domestic water, the groundwater pumped from on-site wells would become unavailable for other purposes such as local wildlife and livestock grazing. If groundwater pumping were to cease, gradual recovery in the water table would be expected. There is not sufficient data available to estimate the recovery rate of any underlying aquifer.

Natural gas requirements would be 5 million cubic feet per day. Electricity would require a constant supply of 30–35 megawatts with daily energy consumption of 840,000 kilowatt hours. Gasoline would be used by motor vehicles at the SRS with an estimated daily consumption of approximately 333 gallons.